Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

MARCH, 1954

TECHNOLOGY DEPT.

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MAR 31 1954
DETROIT

New wire flattening mill accurately shapes 2000 ft. of wire per min.

...with help of TIMKEN® bearings

THE 3-stand wire flattening mill pictured at left, in operation at the Ansonia, Conn. branch of The American Brass Company, rolls up to 2000 feet of brass or copper wire per minute. It reduces the wire and changes its shape by rolling both flatwise and edgewise. To maintain accuracy at high speeds, The Torrington Manufacturing Company uses 62 Timken® tapered roller bearings on the roll necks and on the reduction drives.

Timken bearings hold the roll necks rigid, insure greater accuracy in the finished product. That's because Timken bearings take both the radial and thrust loads in any combination. They also reduce the amount of power required to run the mill because the true rolling motion and smooth surface finish of Timken bearings practically eliminate friction.

On the reduction gears, Timken bearings keep shafts in proper alignment, keep gears meshing accurately with a minimum of wear. There's less chance of breakdowns caused by excessive gear wear.

Always specify Timken bearings in the equipment you build or buy. Look for the trade-mark "Timken" stamped on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

How **THE TORRINGTON MANUFACTURING COMPANY** mounts the roll necks of its 3-stand wire flattening mill on Timken tapered roller bearings to insure greater accuracy in high speed operation, long life and less maintenance.

TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS

NOT JUST A BALL ○ NOT JUST A ROLLER ⊂⊃ THE TIMKEN TAPERED ROLLER ⊂⊃ BEARING TAKES RADIAL AND THRUST →|← LOADS OR ANY COMBINATION →|←

THE THREE CUTLER-HAMMER STARS

★ ★ ★

STAND FOR THREE NEW STANDARDS

☆ *installs easier*

☆ ***works better***

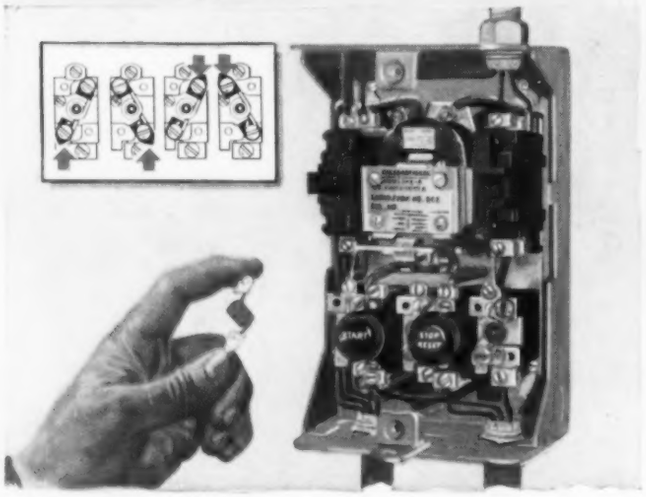
☆ *lasts longer*

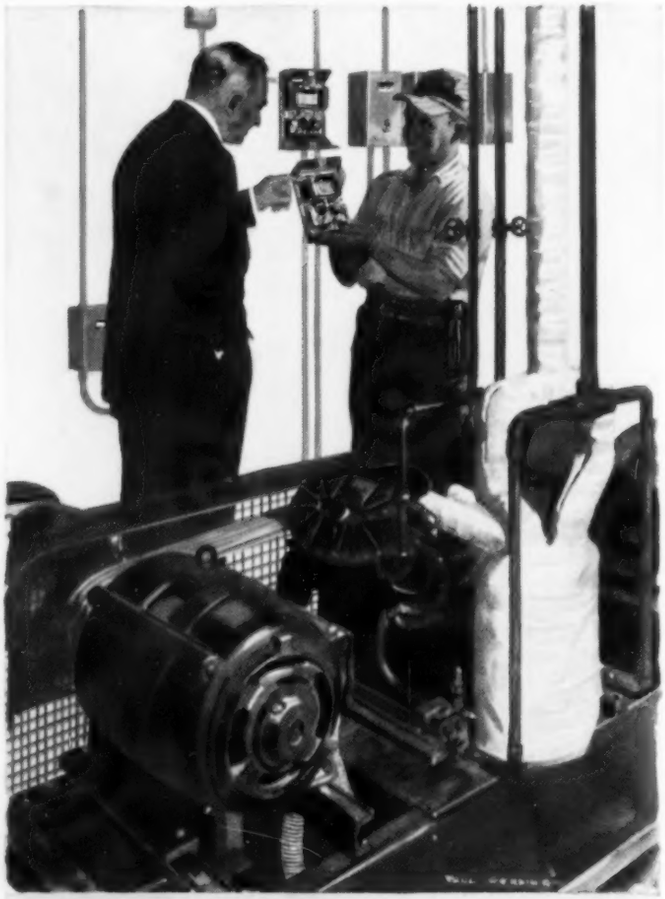
Electrical interlocks...

Up to four extra control circuits may be added by simple installation of interlock blocks. Contacts can be normally open, normally closed, or both. A screw driver is the only tool needed.

Adjustable overload coils...

Each heater coil can be placed in any of four positions to permit adjustment of the overload protection to within 3% of the motor rating...compared to 10% or 12% on competitive control.





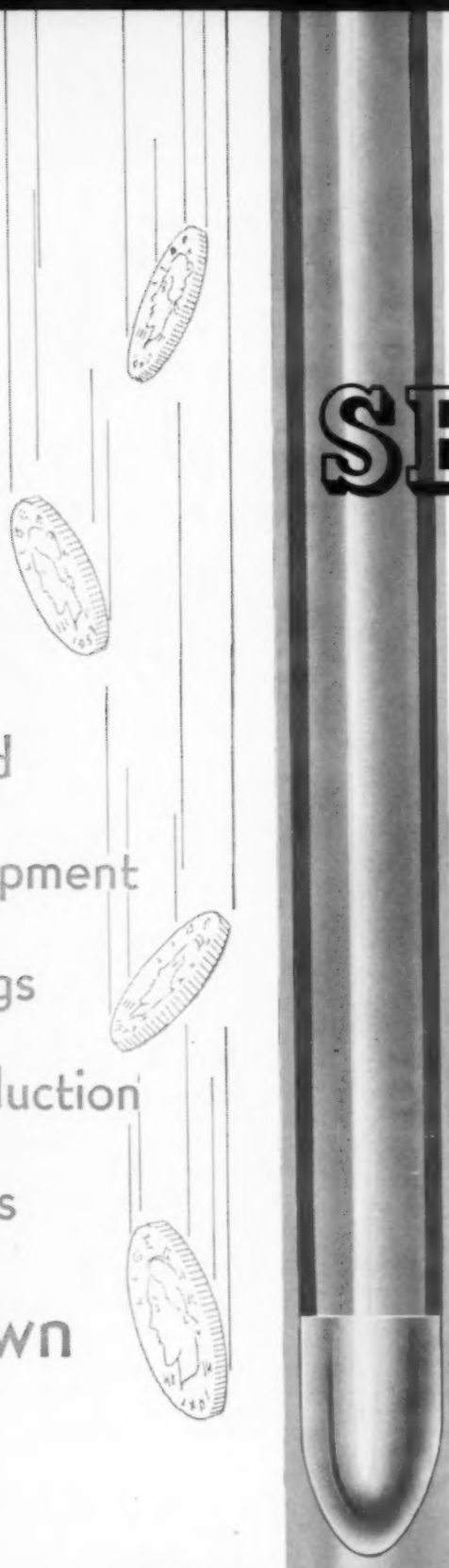
Full three-phase protection...

Another Cutler-Hammer "first." Now the widely demanded three-coil overload protection, so necessary to prevent single-phasing motor burn-outs, is here as an optional feature in standard starter constructions and enclosures. *Complete* 3-Phase protection ...without the high cost of special starter assemblies or the many problems of cumbersome off-size enclosures.

Better performance is more than a mere claim in the spectacular new Cutler-Hammer ☆☆☆ Motor Control. Field tested for more than two years in hundreds of the most difficult jobs before it was ever released for sale. Compared with every make of control by actual users...to have most say, "Better than anything we have ever used." Loaded with new features, a few of which are described all too briefly above. Try it now! Order from your nearby Cutler-Hammer Authorized Distributor today. CUTLER-HAMMER, Inc., 1269 St. Paul Avenue, Milwaukee 1, Wisconsin.

CUTLER-HAMMER ★★★ MOTOR CONTROL

IRON AND STEEL ENGINEER: published monthly by Association of Iron and Steel Engineers, 1010 Empire Bldg., entered as second class matter January 25, 1924 at Pittsburgh, Pennsylvania under Act of Congress, March 3, 1879. $7.50 per year in United States and Canada, $10.00 foreign countries. Volume 31, No. 3.



SEAMLESS TUBE MILLS

good equipment brings production costs down

Every improvement in seamless tube mill equipment has been developed by the combined efforts of the steel industry and Aetna-Standard. That's one reason why Aetna-Standard builds more seamless tube mills than all companies combined. If you contemplate adding tube facilities or revamping existing equipment, call in Aetna-Standard. Such data as costs, rates of production, amortization, equipment details, will give you good information on which to base a decision. **Only from Aetna-Standard can you obtain this authoritative guidance.**

THE AETNA-STANDARD ENGINEERING COMPANY • PITTSBURGH, PA.

Aetna•Standard

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Designers and Builders to the Ferrous, Non-Ferrous, Leather, Rubber, and Plastic Industries

WE HARNESS UNSEEN FORCES . . .

TO GIVE YOU GREATER LIFTING POWER!

The lifted load takes on a "new look" when you swing an EC&M Type SW ALL-WELDED MAGNET into operation. Each lift is wider . . . heavier . . . and a greater pay load.

This *greater* lifting power results from the EC&M all-welded design, which permits better space proportioning for magnet windings and eliminates load-limiting air gaps. When you turn on the current, invisible magnetic lines of force flow radially out from the center pole across the load and back into the magnet case through the outer pole ring. The magnetic path is constant . . . no air gaps at pole shoes.

Whether you are handling pig or scrap iron . . .or any other ferrous materials or products . . . there's an EC&M Type SW all-welded magnet to meet your individual requirements.

CHECK THESE FEATURES: EC&M Type SW all-welded magnets are sealed against moisture . . . inner and outer poles are welded for snug fit . . . pole pieces are renewable . . . wider working surface and bigger pay loads result from elimination of recesses for bolts . . . greater mechanical strength withstands rough handling and assures longer service life . . . maximum operating efficiency means substantial savings in time and results in top economy.

FOR DETAILS AND SPECIFICATIONS, WRITE TODAY FOR BULLETIN 900.

LIFT MORE FOR LESS WITH EC&M LIFTING MAGNETS!

1702

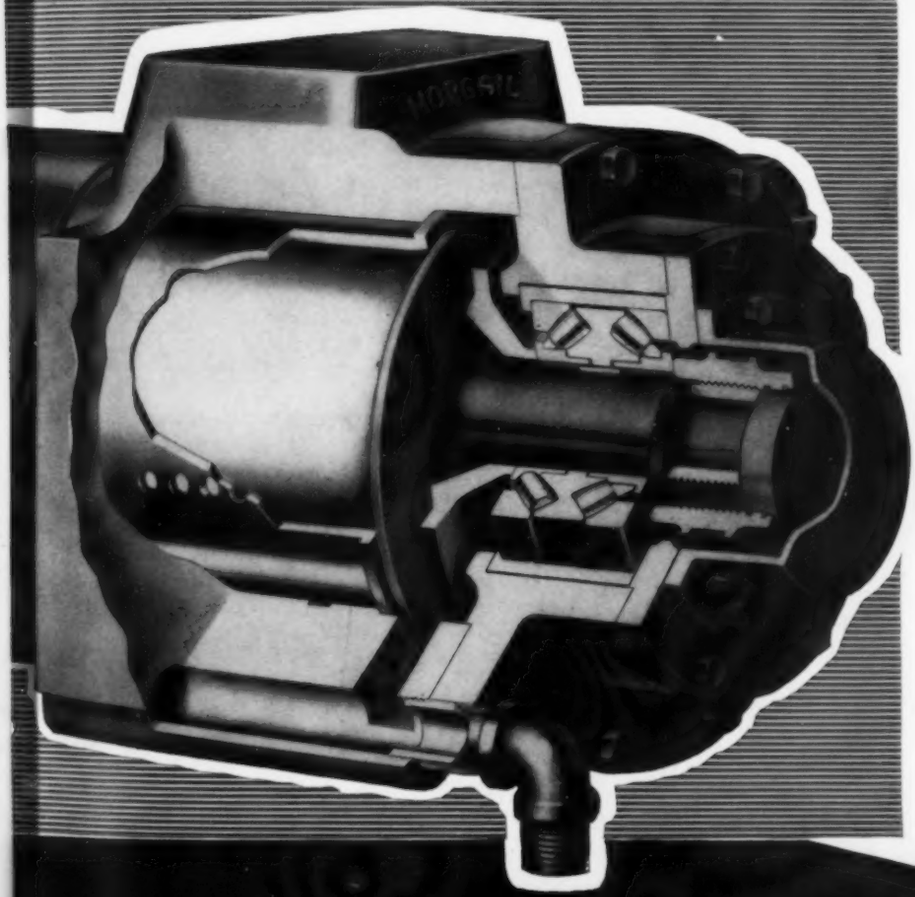
THE ELECTRIC CONTROLLER & MFG. CO.

2698 East 79th Street Cleveland 4, Ohio

Morgoil Adopts Aluminum Alloy

IN 1935, Morgan Construction Company, ever on the alert for improvements in roll neck bearings, was a pioneer in the use of cadmium nickel alloys to replace babbitt as the bearing metal in MORGOIL Bearings.

World War II interrupted our research program but **IN 1946** we turned our attention to aluminum alloy bearing metals. For six years we carried on an extensive investigation in co-operation with the Research and Development Division of the Aluminum Company of America. Aluminum alloy bushings were tested in MORGOIL Bearings on all types of 2-high and 4-high mills in the plants of many of our customers and have definitely proved their superiority under the most grueling of operating conditions. **IN 1952** our production of bushings was changed to the aluminum alloy type. We are confident that this marked another important milestone in the development of the most rugged, most dependable and most economical roll neck bearing — MORGOIL.



●

MORGAN CONSTRUCTION CO.

WORCESTER, MASSACHUSETTS

ROLLING MILLS - MORGOIL BEARINGS
WIRE MILLS - GAS PRODUCERS - AIR EJECTORS
REGENERATIVE FURNACE CONTROL

English Representative: International Construction Company, Ltd.
56 Kingsway, London, W.C. 2, England

MB-25

MORGOIL
ROLL NECK BEARINGS

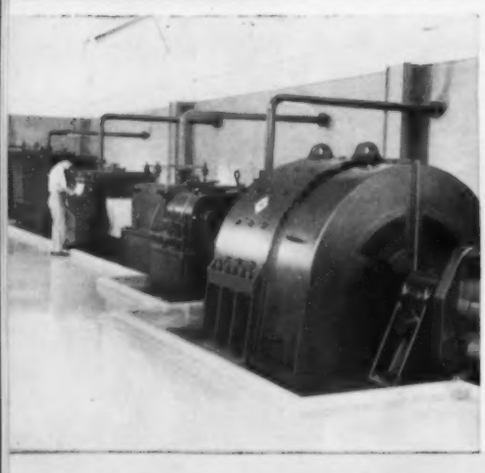
Continental Steel's

Now in Operation

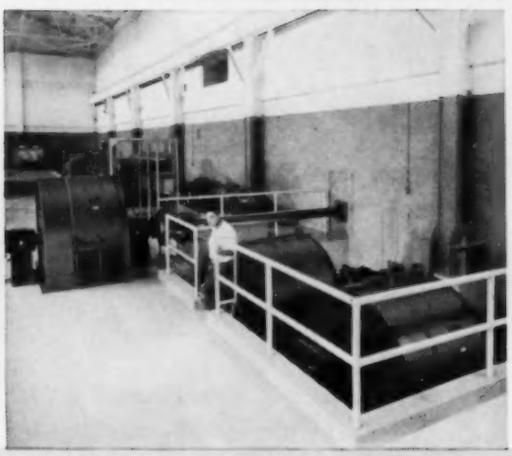
ALLIS-CHALMERS

Rolling Mill Equipment

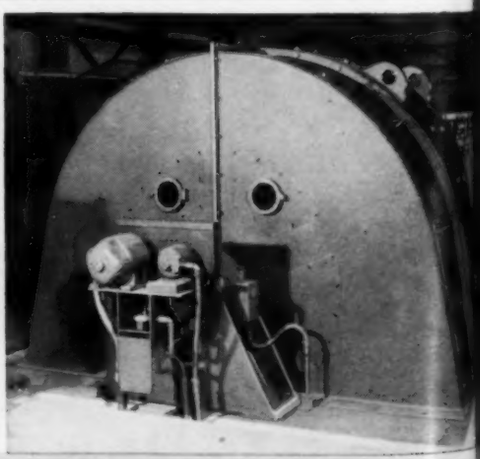
Motor room for continuous rod mill. Allis-Chalmers equipment, including drive motors, series exciter sets, *Regulex* sets, switchgear, motor-generator sets and transformers, furnishes coordinated power to hold precision speeds required in rod mill operation.



Roughing stand drives in the motor room. The 400-hp, 300/900-rpm dc motor in the background drives stands 1 and 2, and the 1500-hp, 300/750-rpm dc motor in the foreground drives roughing stands 3 through 8.



Intermediate stand drives in motor room. Three of the four 800-hp, 300/900-rpm dc motors driving stands 9 through 16. Larger rods are taken directly from these stands without passing through the finishing stands.



Finishing stand drive in the mill proper. This Allis-Chalmers 2000-hp, 300/600-rpm dc motor drives stands 17 through 22. Any number of these six stands may be used to run a variety of small rod sizes.

NEW ROD MILL
at Kokomo, Indiana

AN IMPORTANT PART of Continental Steel Corporation's expansion program to satisfy growing demands for their wire products is the specially designed Allis-Chalmers equipment controlling and driving the 22 stands in this all-new continuous rod mill.

Allis-Chalmers motors and controls are responsible for furnishing the precision speeds required in processing rod from billet to finished product. Each stand must be perfectly coordinated with the others to receive and pass rod from a starting speed equal to a walk and progressing to a finishing speed approximating 60 miles per hour.

Simplified Control

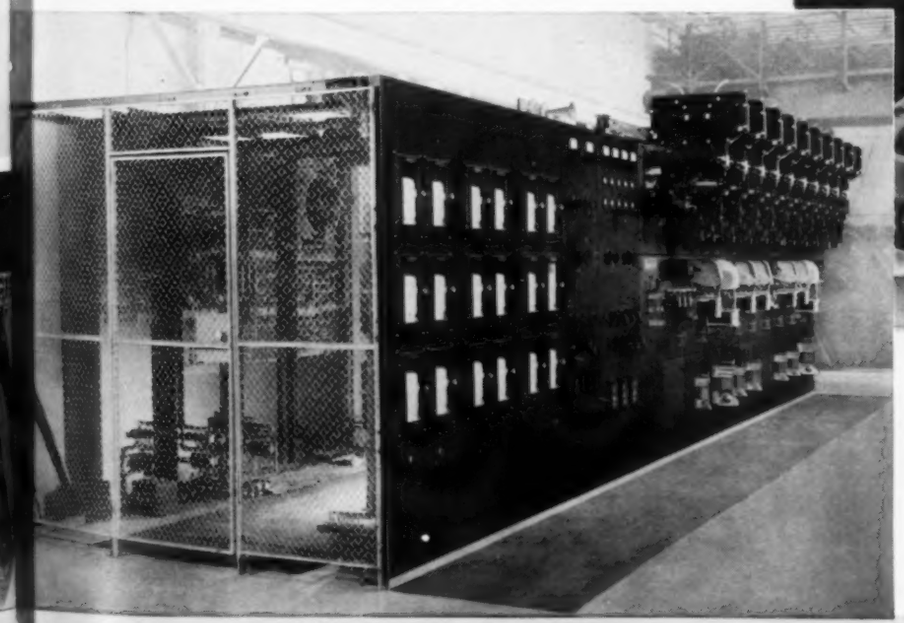
The seven drive motors are standard rolling mill types, engineered to meet the mill requirements and to operate through a simplified speed control system regulating motor field circuits with individual series exciters. Satisfactory mill operation, running three rods simultaneously, has produced 24 coarse and fine rod sizes from 0.218 to 0.681 inch, with projected use up to 1.125 inches.

This mill system gives Continental the benefits of flexibility and adaptability, with quality control not limited to a particular product size. Simplified control and durability are features Allis-Chalmers engineers have used to assure low maintenance costs.

For specific information on control, drives, and other electrical equipment to meet the needs of your expansion or conversion program, contact A-C office nearest you or write to Allis-Chalmers, Milwaukee 1, Wisconsin. A-4151

Regulex is an Allis-Chalmers trademark.

Pulpit control for rod processing. From this vantage point the operator controls stand speeds varying from 38 to 114 feet per minute at the start of roughing, to finishing speeds of 5000 feet per minute.



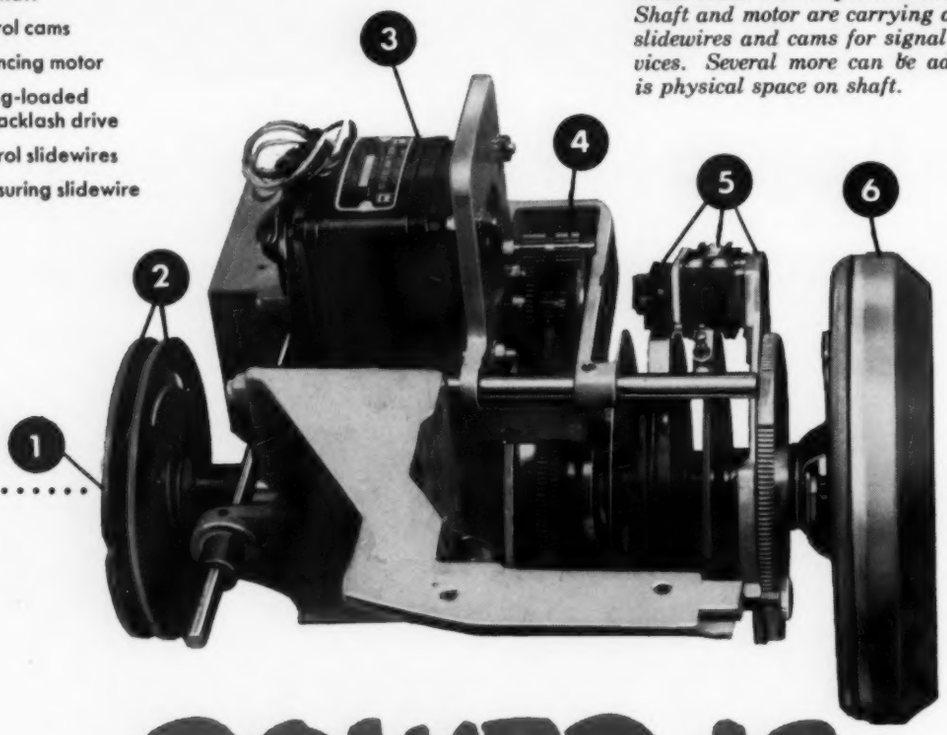
Variable voltage control panel (left) in the motor room for the main drive motors.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

Power, Electrical, Processing Equipment for Iron and Steel

1. Center line of slidewire and shaft
2. Control cams
3. Balancing motor
4. Spring-loaded no-backlash drive
5. Control slidewires
6. Measuring slidewire



This partially dis-assembled view of Speedomax shows its simple line-shaft construction. Shaft and motor are carrying a partial load of slidewires and cams for signal and control devices. Several more can be added; only limit is physical space on shaft.

POWER IS PERFORMANCE

...and Speedomax® Instruments lead with "huge" 12-watt balancing motors!

■ Today's Speedomax instruments provide from 2 to 4 times more power in their balancing motors than do any other available electronic controllers, recorders or indicators.

Because of this power, you'll find the instrument exceptionally fast, agile and dependable, whether the task is routine or unusual.

Do you want to control a process automatically on a time-temperature program—heat, hold and cool at specified rate? We'll put all the extra "gear" on the instrument; give you program control by either of the two standard methods (cam-operated or motor-operated); actuate the control valve by either air or electricity; and the whole set-up will operate as effectively as the simplest on-off control.

And if you want another meter, somewhere else in the plant, to show what's going on in the process, we'll put another slidewire on the instrument's $\frac{3}{8}$" steel shaft, feed it and the remote meter with a "clean" electric supply and give you remote information that you can't tell from the original. *Because of the ample power, you don't lose sensitivity when you load a Speedomax.*

An ample safety factor is as useful in an instrument as in any other industrial equipment. Why not investigate Speedomax for your plant's electronic potentiometers and bridges? You'll find the types described in Catalog ND46(1), and additional information about unusual industrial and scientific uses in Technical Publication ND46. Either or both will be sent on request to our nearest office or to 4942 Stenton Ave., Phila. 44, Pa.

LEEDS NORTHRUP
instruments automatic controls • furnaces

CONTINENTAL

RAIL and STRUCTURAL MILLS

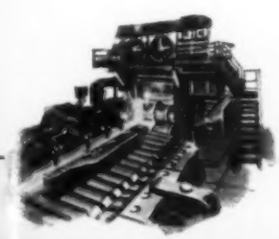
Complete Rolling Mill Installations

SLABBING MILLS	Mills complete with Auxiliary Equipment	BLOOMING MILLS
UNIVERSAL MILLS		STRUCTURAL MILLS
PLATE MILLS	★ ★ ★	RAIL MILLS
HOT STRIP MILLS	CONTINENTAL CHIPPER	BILLET MILLS
COLD STRIP MILLS	ROLL LATHES	ROD MILLS
TEMPER MILLS	SPECIAL MACHINERY	MERCHANT MILLS

CASTINGS—carbon and alloy steel from 25 to 300,000 pounds

ROLLS—iron, alloy iron and steel rolls for all types of rolling mills

WELDMENTS—fabricated steel plate or cast-weld design



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available to

PRODUCERS and PROCESSORS

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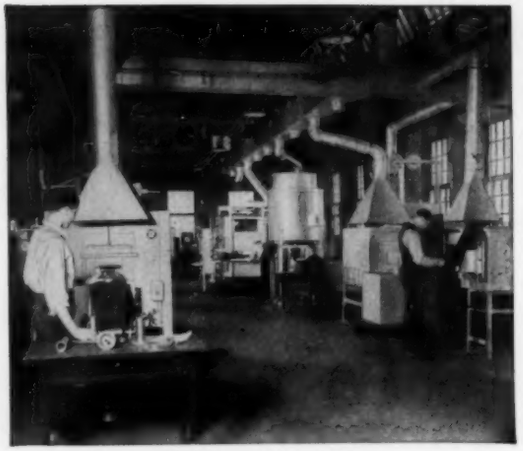
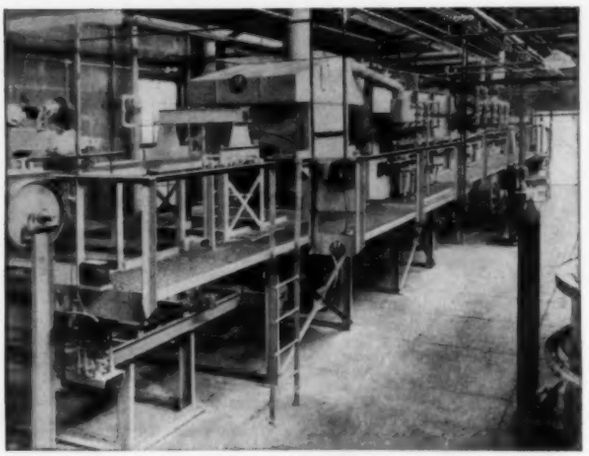


General view of the research department showing several of the continuous and batch type experimental furnaces.



View of combination gas-fired and electric continuous furnace equipped with flame preheating burn-off or oxidizing section and controlled heating, soaking and cooling zones, for producing various surface conditions on strip.

● The EF research department is equipped with gas-fired, oil-fired and electrically heated continuous and batch units including,— continuous wire mesh furnaces;— endothermic and exothermic special atmosphere generators; — forced circulation bell furnaces; — a continuous roller hearth furnace for treating commercial widths of ferrous and non-ferrous strip; — and other equipment.

Consequently, — from test runs — we can determine accurately the combination of temperature, time cycle, atmosphere and other factors needed to produce the exactly desired result,— assuring — in advance — the efficient performance of EF furnaces *fully up to specification.*

Many large companies have drawn liberally upon this department in developing new products, and new techniques. Our facilities are available to YOU also — for YOUR research or development work, either gratis or for a moderate fee, depending upon the nature of the experiment. We will be glad to schedule time for your technicians, or write today for our 12 page booklet, "Research Facilities". It describes the equipment we can place at your disposal.

Direct gas-fired forced circulation bell type furnace for processing wire, rod, strip and other products.

Gas-Fired, Oil-Fired EF ***and Electric Furnaces***

for any Process, Product or Production

THE ELECTRIC FURNACE CO.

WILSON ST. at PENNA. R. R. *Salem - Ohio*

Canadian Associates • CANEFCO LIMITED • Toronto 1, Canada

OVER A MILLION TONS OF STEEL HANDLED ANNUALLY AT U.S. STEEL'S DUQUESNE WORKS

—by ROSS *Carriers*

Running the roads and arteries of U. S. Steel's huge Duquesne Works is a team of seven Ross Carriers and two Ross lift trucks—fast, mobile, well suited to handling over a million tons of steel according to precision-engineered plan.

Quickly dispatchable by radio to any point, the Ross Carriers haul their loads of blooms and billets, and handle semi-finished steel between conditioning yards, stockfield areas and finishing mills. The Ross lift trucks work effectively with the Carriers—moving and piling smaller loads, and removing them as needed for rolling orders.

Formerly, steel had to be handled up to seven times by locomotive and crane from primary to secondary mills. Now, steel is at the finishing mills, usually after only two rides on a Ross—never more than four. The carriers also move ingots, scrap in charging boxes, and maintenance spares. In addition, storage space inaccessible by crane is now put to good use.

Are not these time-saving, money-saving advantages, built into Ross Carriers, waiting discovery in your business? Why not call in the Ross dealer to help find your own substantial benefits. Call him.

CLARK EQUIPMENT

ROSS CARRIER LINE
Industrial Truck Division
CLARK EQUIPMENT COMPANY
Benton Harbor 135, Michigan

SLAB TURNING GANTRIES . . . *by "Shaw-Box"*

Slab Turning Gantries are another specialty in the broad "Shaw-Box" Line of steel mill cranes. Numerous outstanding mechanical advantages are contained in them. Among these mechanical advantages are a perfected ratchet device that disengages the hoisting mechanism if the load is carelessly handled preventing trolley being raised off the bridge when engaging slabs; roller guides to guide the ram and prevent swing of mast; a ram that can be removed without disturbing the operating mechanism.

In "Shaw-Box" Slab Turning Gantries — whether built to an individual mill's or A.I.S.E. specifications — you get the added advantages that come from "Shaw-Box" engineering, fine workmanship, and precision manufacturing methods. These added advantages insure crane performance which makes "Shaw-Box" Gantries, for the work they do, the least expensive cranes to buy and use.

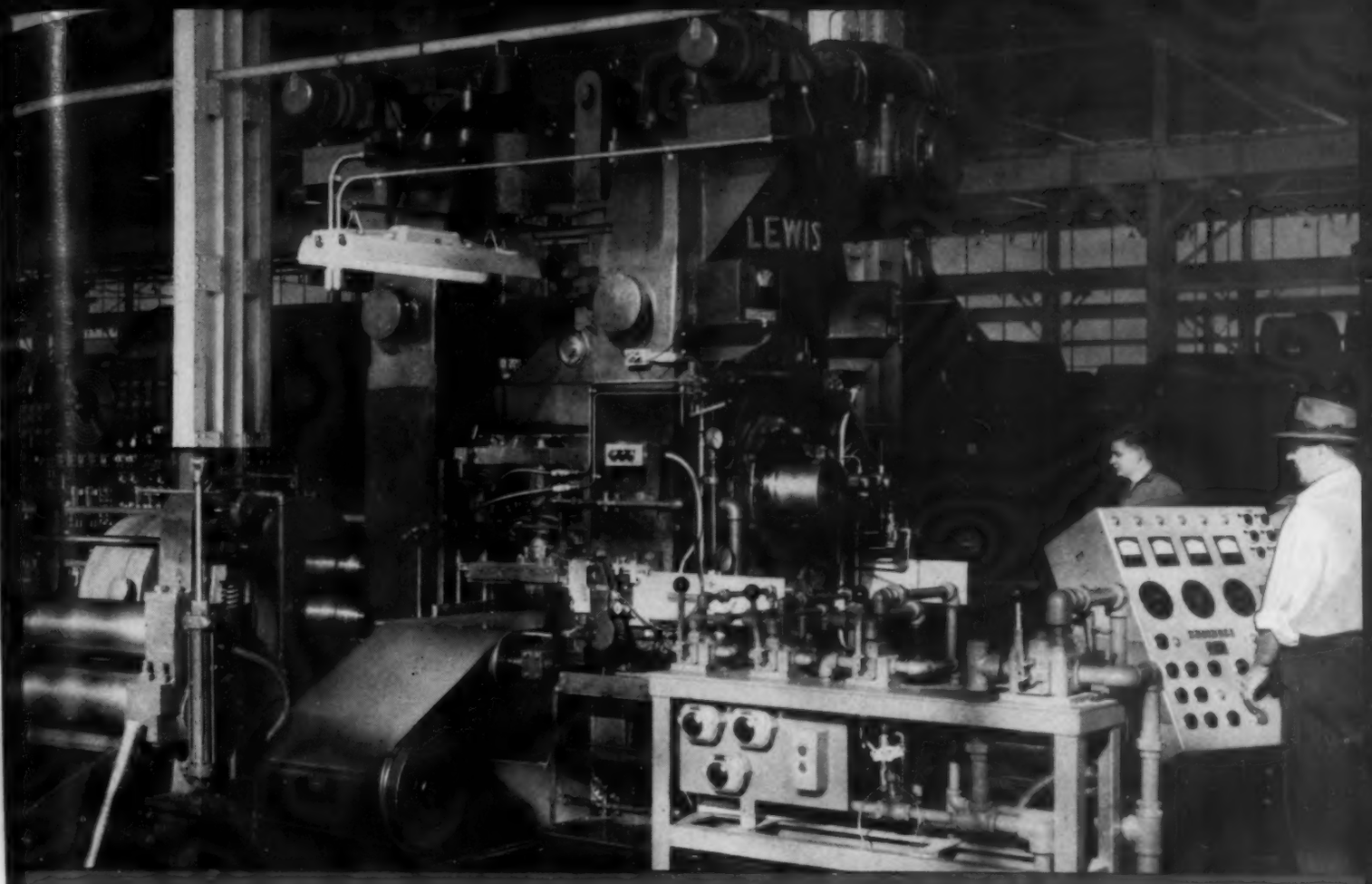
SEND ALL YOUR INQUIRIES FOR STEEL MILL CRANES AND SOAKING PIT CARRIAGES TO "SHAW-BOX"

"Shaw-Box" CRANES

MANNING, MAXWELL & MOORE, INC.

Muskegon, Michigan

Builders of "Shaw-Box" Cranes, 'Budgit' and 'Load-Lifter' Hoists and other lifting specialties. Makers of 'Ashcroft' Gauges, 'Hancock' Valves, 'Consolidated' Safety and Relief Valves, 'American' Industrial Instruments and Aircraft Products.



standard stock items cold re-rolled to customer requirements

Often times a customer wants steel strip that's not a regular stock item . . . such as a different width, gauge, temper or finish. And he wants it fast.

That tough sales situation was solved by a well-known Detroit distributor. They installed a Lewis 10″ and 26″ x 28″ four-high reversing Cold Strip Mill in their warehouse several years ago. The first mill proved so profitable, they have since installed two more.

This Lewis Cold Strip Mill has the capacity for cold reducing hot roll steel strip approximately 25 to 30% maximum per pass . . . starting with 11 gauge stock in any widths up to the capacity of the mill. It readily handles coils weighing 300 pounds per inch of width at mill speeds of 400 to 1000 feet per minute.

Reversing coils permit continuous operation with substantial reductions per pass. Latest type push-button controls maintain close gauge tolerances. These two features, plus the necessary annealing equipment, provide operating setups that are flexible enough to meet all customer requirements.

Although originally designed to meet these special requirements, this mill has proved to be a high-production unit in other services. We'll be glad, at any time, to give you more complete information on design and specifications of this Lewis four-high reversing Cold Strip Mill.

In fact, our experienced engineers and modern manufacturing facilities are always available . . . to help you solve any problem which includes rolling mill machinery.

LEWIS four-high reversing COLD STRIP MILL

BLAW-KNOX

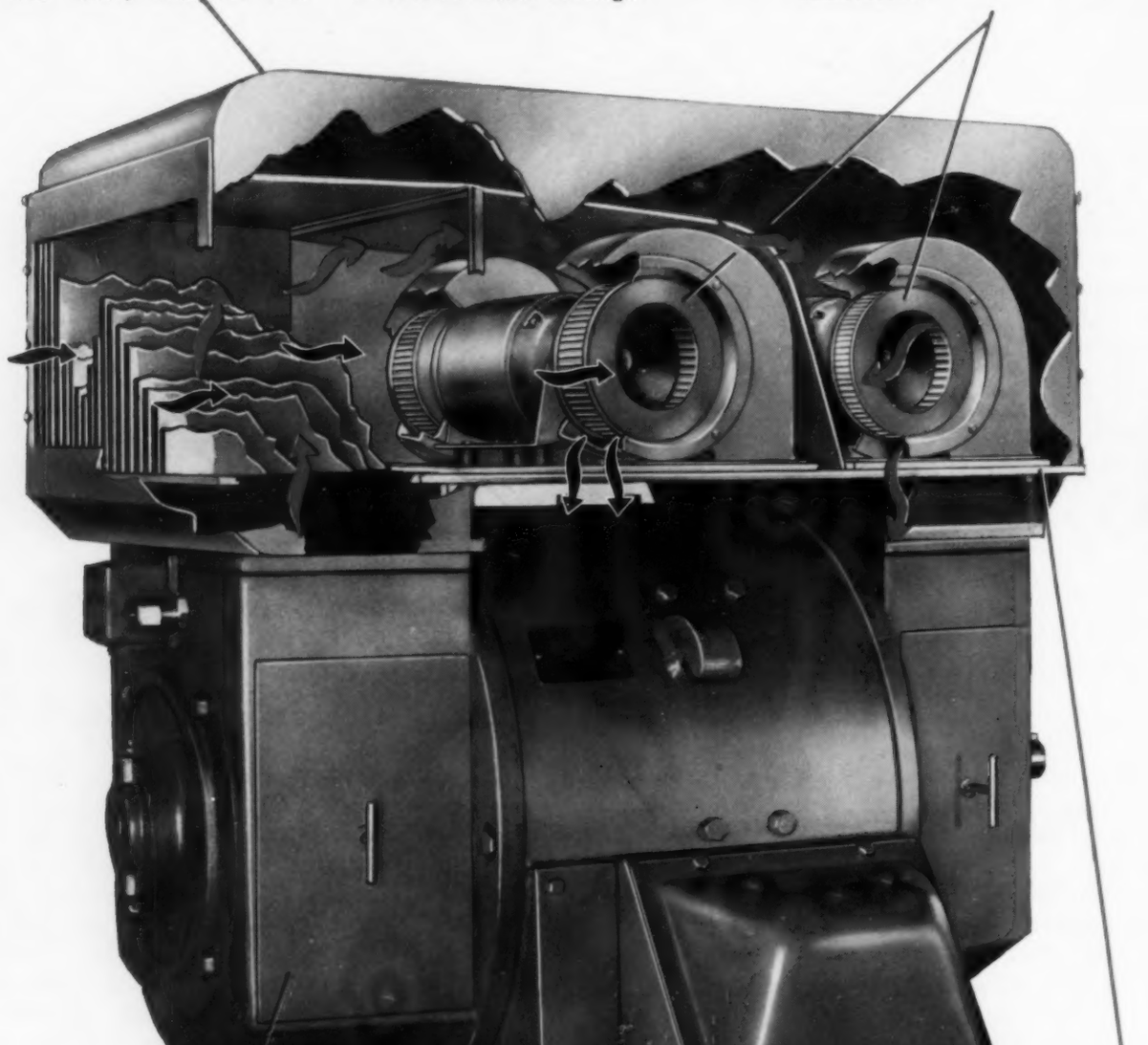
BLAW-KNOX COMPANY • LEWIS MACHINERY DIVISION
PITTSBURGH 22, PENNSYLVANIA

LEWIS PRODUCTS: Two-High Mills • Three-High Mills • Four-High Mills • Bar and Billet Mills • Rod Mills • Coilers • Tables • Shears • Levelers • Pinion Stands • Gear Drives • Roll Lathes • Flaking Mills

NEW G-E UNIT-COOLED

DOUBLE VENTILATION SYSTEM: Outside room air (black arrows) enters cooling unit through external portion of the heat exchanger. This air cools the exchangers inner walls, which in turn cool the permanently trapped air. Clean air (red arrows) remains within the unit and never mixes with outside room air. End blower continuously circulates clean air over the motor windings.

TWO BLOWERS operate the double ventilation system and are powered by separate General Electric totally-enclosed fan-cooled motors independent of the main motor.



INSPECTION OPENINGS are gasketed for extra protection. They are easily accessible with no tools required.

COMPACT, top-mounted cooling unit, 37% smaller than previous models, falls within over-all length and width of main motor and is easily removed if necessary.

Progress is our most important product

GENERAL ELECTRIC

D-C MOTOR

Gives you the benefits of d-c speed control — the protection of totally enclosed construction.

WHAT IS THE UNIT-COOLED D-C MOTOR?

It is a Type CD machine with an integrally mounted air-to-air-heat exchanger. Within the exchanger are two separate blower assemblies which operate the unit's double ventilation system. Permanently trapped air cools the motor and in turn is cooled by the outside air being pulled through the heat exchanger.

WHERE DO YOU USE IT?

The new G-E Unit-cooled d-c motor is specifically designed for environments which make open or partially enclosed motors difficult or expensive to maintain. When dampness, metal particles, dust, dirt, oily vapors, fly ash or other harmful airborne materials are present, this new, better protected motor offers real operating economies.

WHAT ARE ITS ADVANTAGES?

WIDE SPEED RANGE OPERATION. Independent ventilation system allows full use of inherent speed ranges of the d-c motor. Ventilation is not dependent upon main motor speed.

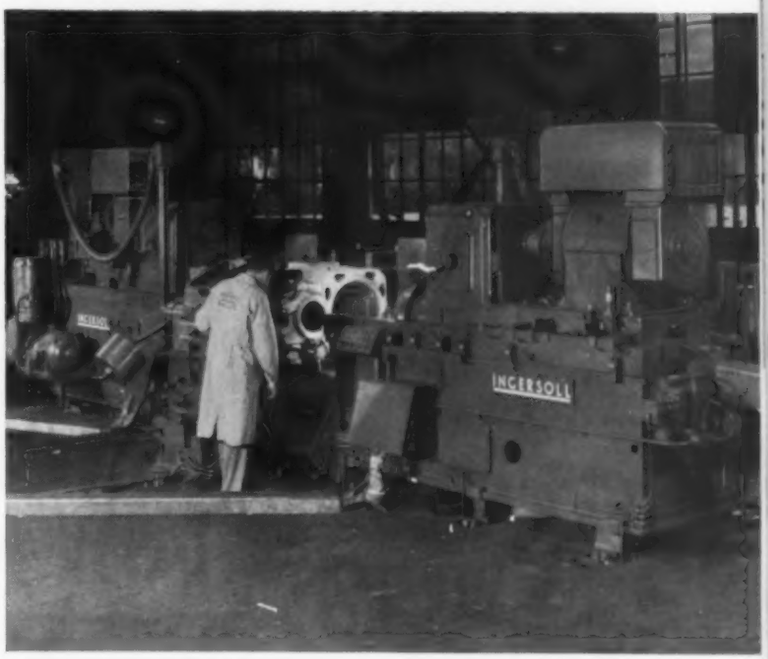
LOWER INSTALLATION COST. Unit has no external duct work, blowers or air filters to install. A completely self-contained unit, it can be relocated or replaced easily and quickly.

LESS MAINTENANCE. There are no air filters to replace or clean. Self-cleaning vertical heat exchanger plates are used instead of horizontal type. Inspection doors are gasketed and easily accessible with no tools needed.

SMALLER SIZE. Unit-cooled d-c motors are built in smaller frames than non-ventilated or fan-cooled motors of the same rating. This gives you smaller size, less weight and lower armature inertia which is important in applications which require frequent and rapid speed changes or reversals.

AVAILABLE IN *ALL* STANDARD RATINGS from 15-200 hp, in constant and adjustable speed types. For more information on the new G-E Unit-cooled motor, contact your nearest G-E Apparatus Sales Office or fill out the attached coupon for a copy of the Unit-cooled motor bulletin. General Electric Co., Schenectady, N. Y.

MOUNTS AT ANY ANGLE. Here two G-E Unit-cooled d-c motors drive a boring machine used for boring diesel engine blocks.



NO DUCTS OR PIPING. Ventilation system of G-E Unit-cooled d-c motor is self-contained. Smooth lines facilitate cleaning.

General Electric Co.
Section E 810-1
Schenectady 5, New York

Please send me a copy of Bulletin GEA-6091 on the new G-E Unit-cooled d-c motor.

( ) for planning an immediate project
( ) for reference only

NAME.....

COMPANY.....

ADDRESS.....

CITY..... **STATE**.....

7 solid reasons why it pays to standardize on LINK-BELT IDLERS

1 STRONG, RIGID FRAMES support rolls in perfect alignment. Rolls are securely held in place but can be easily removed for inspection and service.

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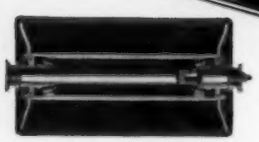

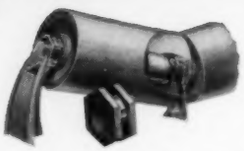

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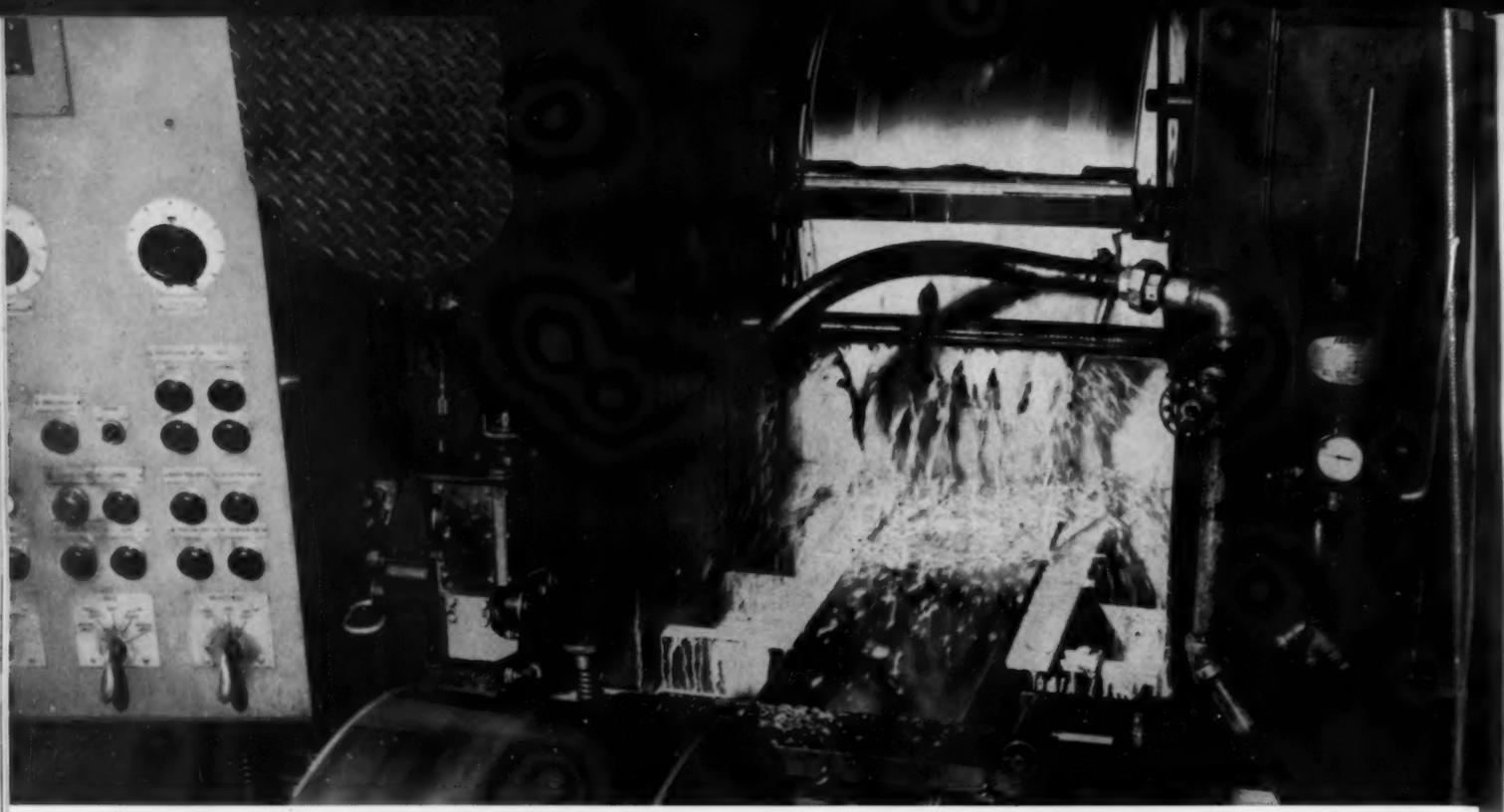

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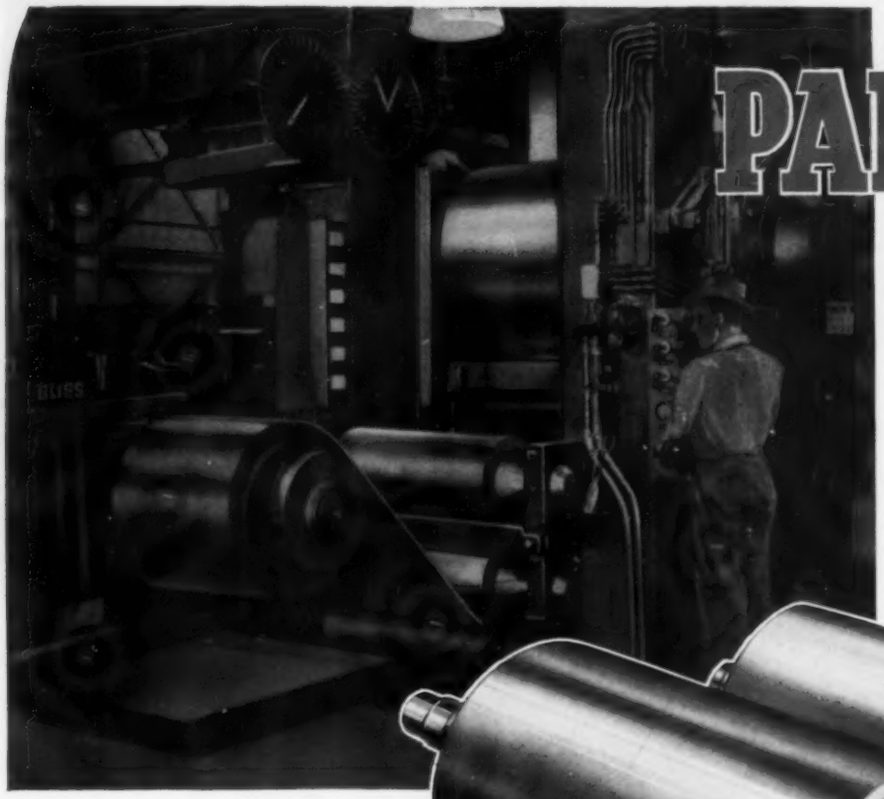

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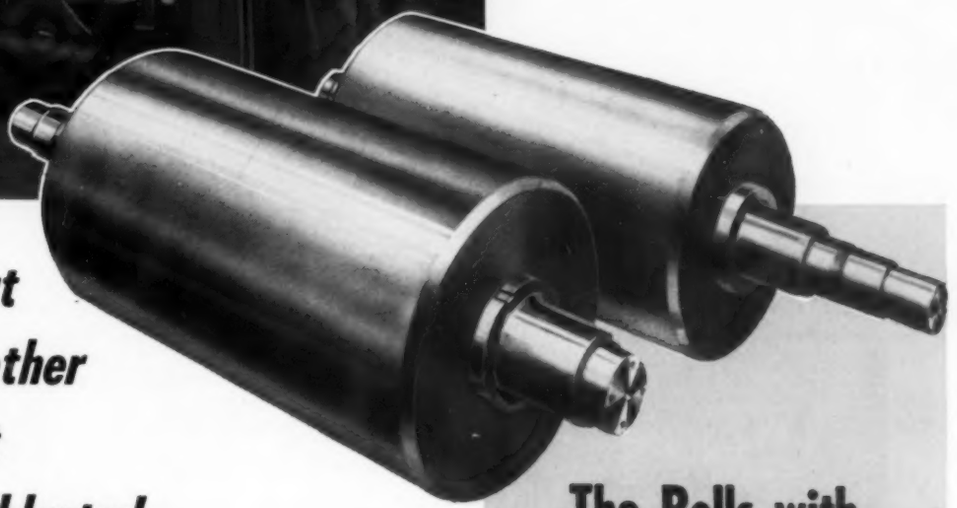

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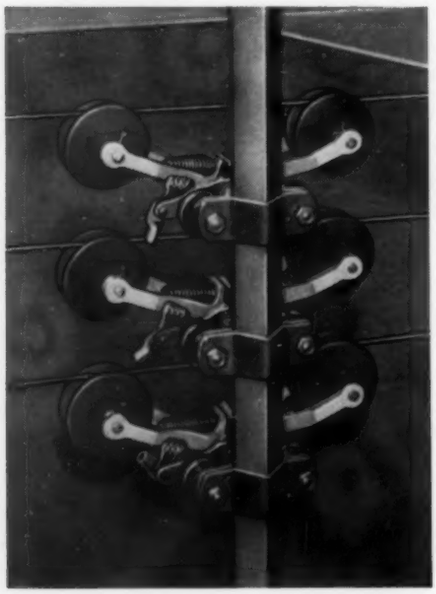

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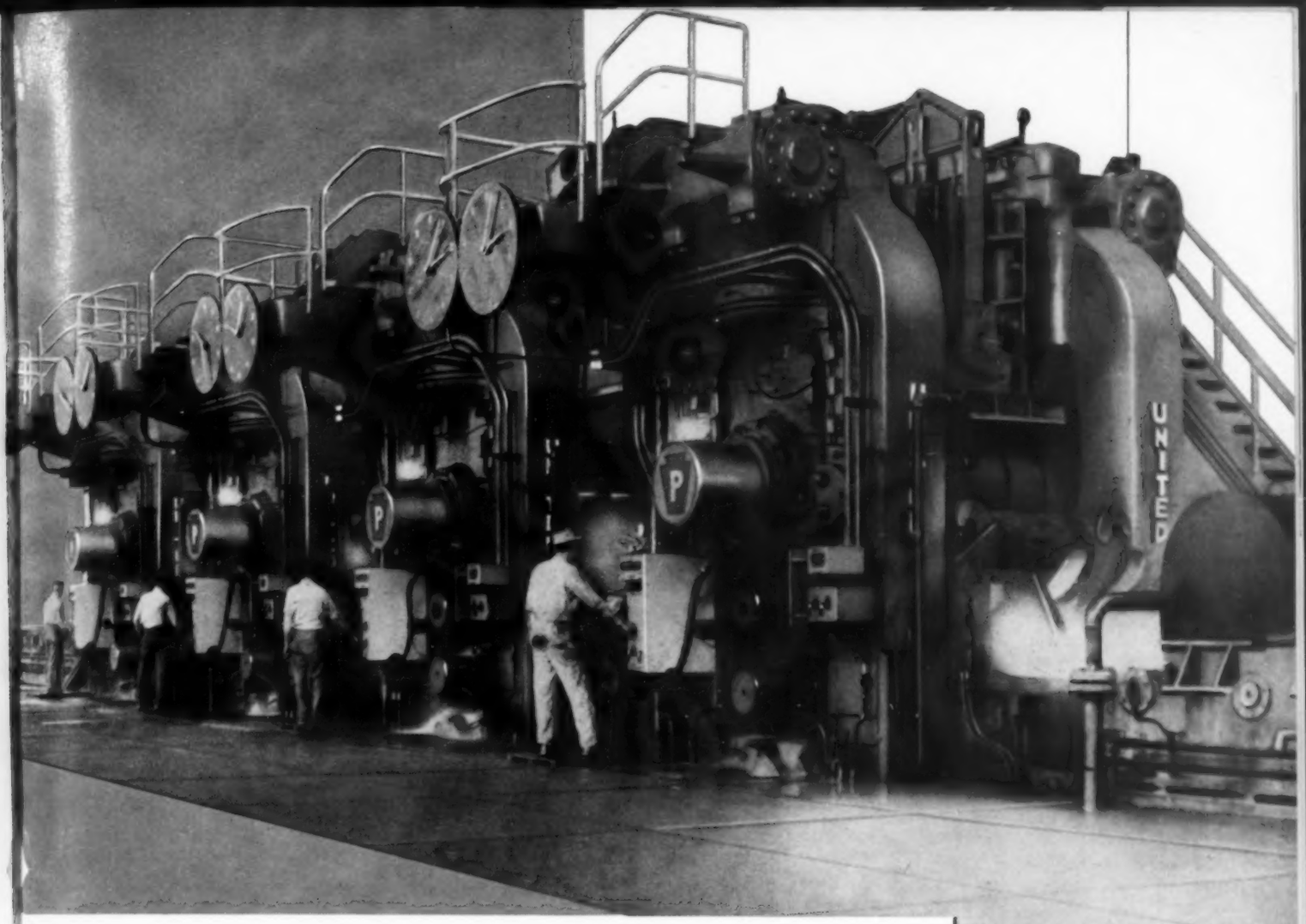

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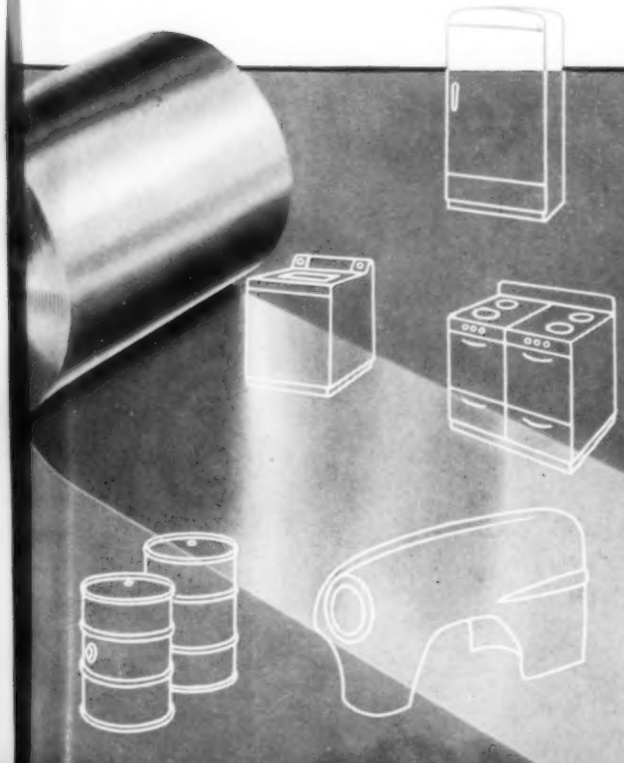

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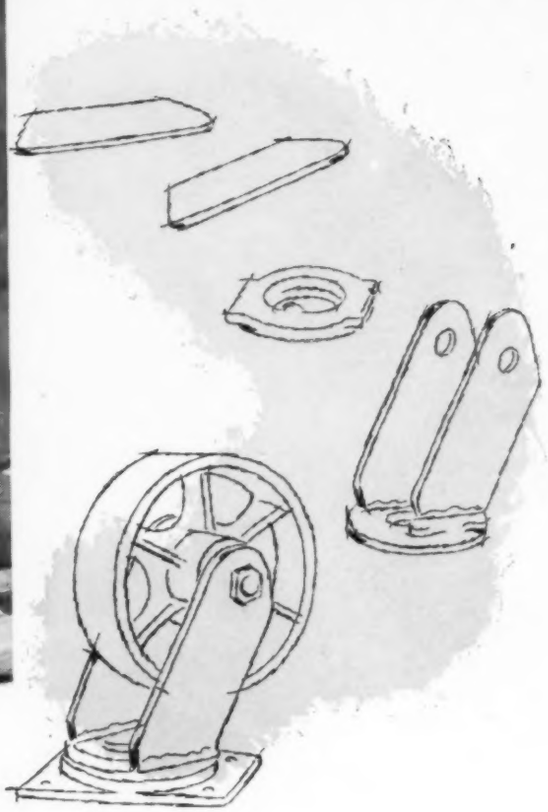

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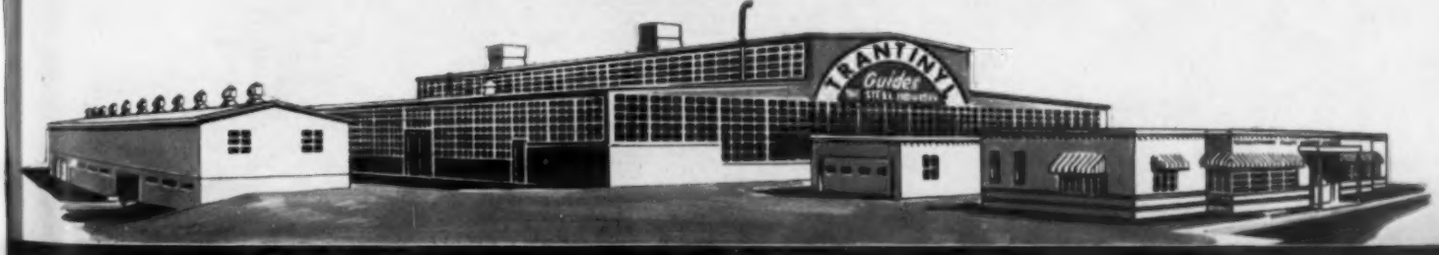

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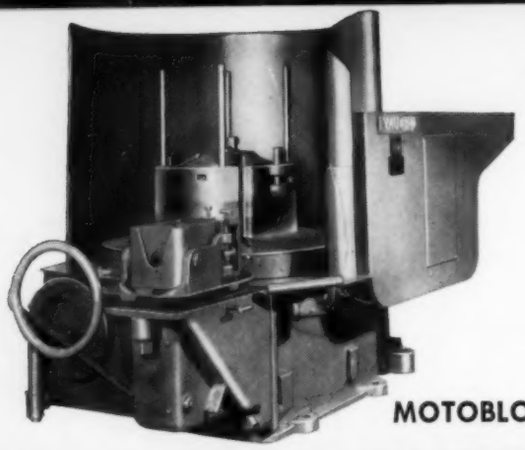

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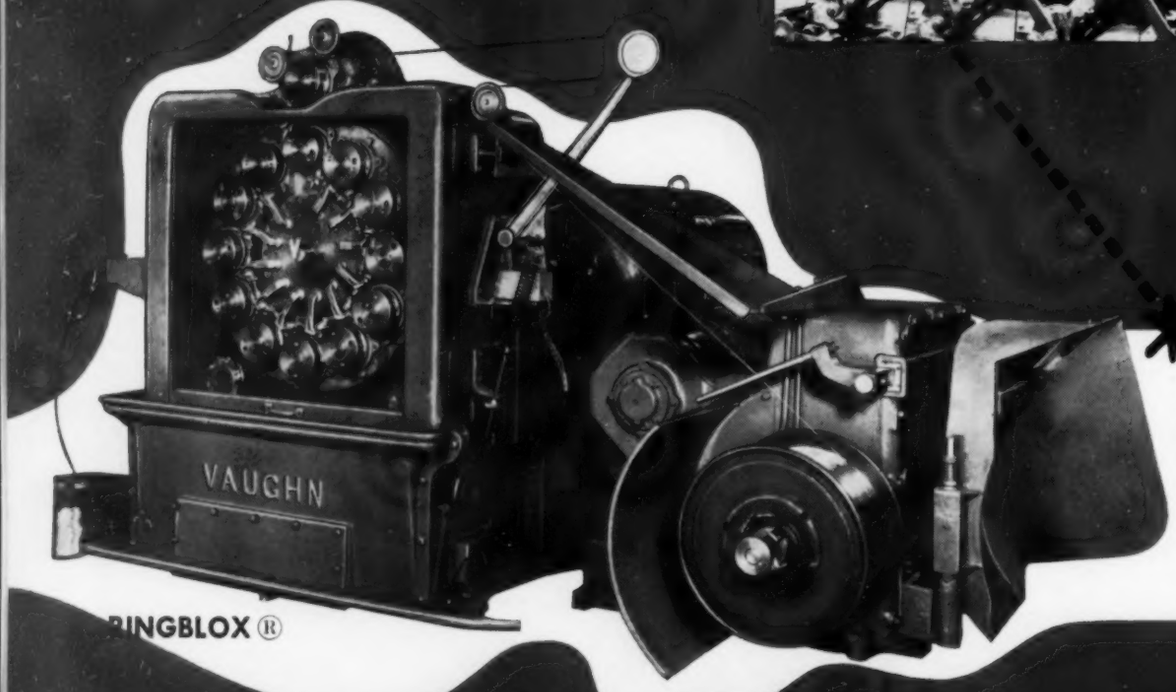

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Patent Reviews

By MELVIN NORD
Patent Attorney
Detroit, Mich.

. . . . copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents each . . . patents reviewed cover period November 10, 1953 through December 1, 1953 . . . .

METHOD OF BLOWING-IN BANKED BLAST FURNACES

▲WHEN a blast furnace is shut down for a prolonged period, it is usually "banked," that is, it is charged with coke only, and its tuyere openings are sealed. Stack effect alone is relied on to maintan slow combustion and thus keep the furnace hot. The usual method of starting a banked furnace is to blow air, optionally enriched with oxygen, through some of the tuyeres adjacent to the iron notch, and sometimes through the iron notch itself. The main difficulty is in remelting the mass of material that accumulates on the furnace bottom. It is often necessary to cast iron several times from the cinder notch before this mass is sufficiently molten to cast from the iron notch. Commonly the blowing-in period consumes at least 48 hours before the bottom is hot enough to permit proper operation.

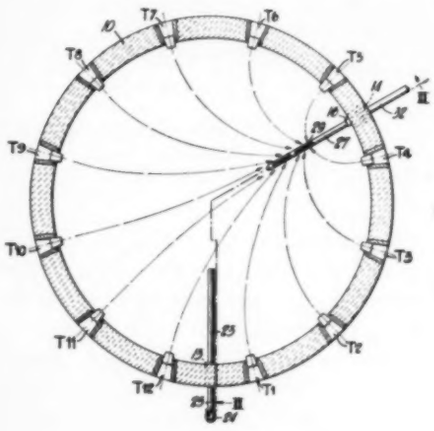


Figure 1

According to William A. Abbett, Jr. and Floyd C. Diaz in U. S. 2,660,524, it has been found that previous methods of blowing-in banked furnaces do not distribute the heat properly in the regions where it is needed. Only the periphery of the furnace a few feet in front of the tuyeres and iron notch is heated sufficiently during the blowing-in period. The rest of the furnace bottom does not readily become hot enough to clean out the burnt coke, heavy scrap, and scabs along the furnace walls. In U. S. 2,660,524, an improved furnace starting method is described which conserves heat in the furnace bottom, thereby shortening the time for blowing-in. The patent, issued Nov. 24, 1953, is assigned to United States Steel Corp.

Figures 1 and 2 show part of a blast furnace of usual construction which includes a wall 10, twelve tuyeres T-1 to T-12, an iron notch 13, and a cinder notch 14. The cinder notch has a large cinder cooler 15, an intermediate cooler 16 and lugs 17. The furnace has the usual bustle pipe 18, tuyeres stocks 19 and blowpipes 20 for supplying preheated air to the tuyeres during normal operation. The furnace is banked and the bottom contains skull 21 around the outside and coke 22 in the central region.

The skull is dug out opposite the iron notch 13. A pipe 23 is inserted through this notch and into the coke 22. This pipe is connected with one of the tuyere stocks via piping 24, which contains a valve 25 and a pressure gage 26. All the tuyeres are sealed. The top portion of the furnace is

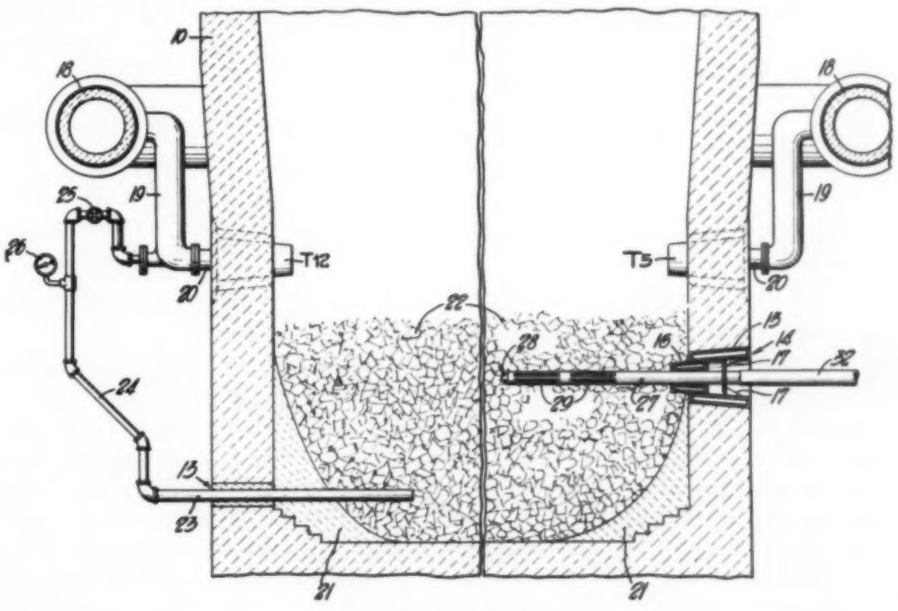


Figure 2

pressurized to keep gases from escaping via this route. It is usually sufficient merely to adjust the bleeder valves for this purpose. To furnish an escape for the gases, a horizontal pipe 27 is inserted through the coolers 15 and 16 of the cinder notch 14 into the coke. As shown in Figures 3 and 4, the pipe 27 has a compressed inner end 28, inlet slots 29 in its sides, and an annular flange 30 at its outer end. This flange has notches 31 in its circumference adapted to receive the cooler lugs 17 to hold the pipe in

Figure 3

place. A larger pipe 32 is placed over the outer end of the pipe 27 to direct the flow of the escaping gases. Combustion is mainly confined to the lower part of the furnace, since there is no escape route for the gases through the top. Instead gases can escape only in a horizontal direction through the pipe 27.

When the initial heat is applied, the tuyeres are opened at intervals after the pressure builds up, as indicated on the gage 26. The first tuyeres opened are T-12 and T-11, which are adjacent to the iron notches on the side opposite the cinder notch. The other tuyeres are opened in sequence around the furnace after appropriate intervals. As each tuyere is opened, the blast is increased and the top pressure increased to compensate for the greater air volume. After several tuyeres are open, the iron notch can be plugged and the blast introduced exclusively via the tuyeres, and still later the pipe 27 can be removed and the gases discharged through the furnace top.

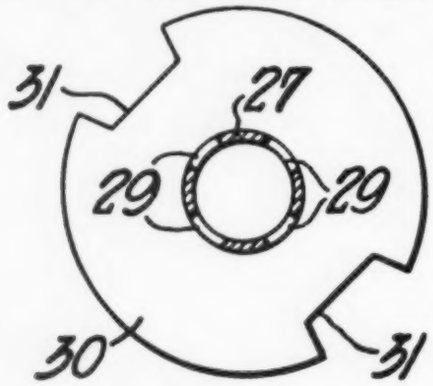


Figure 4

OTHER PATENTS OF INTEREST TO IRON AND STEEL ENGINEER

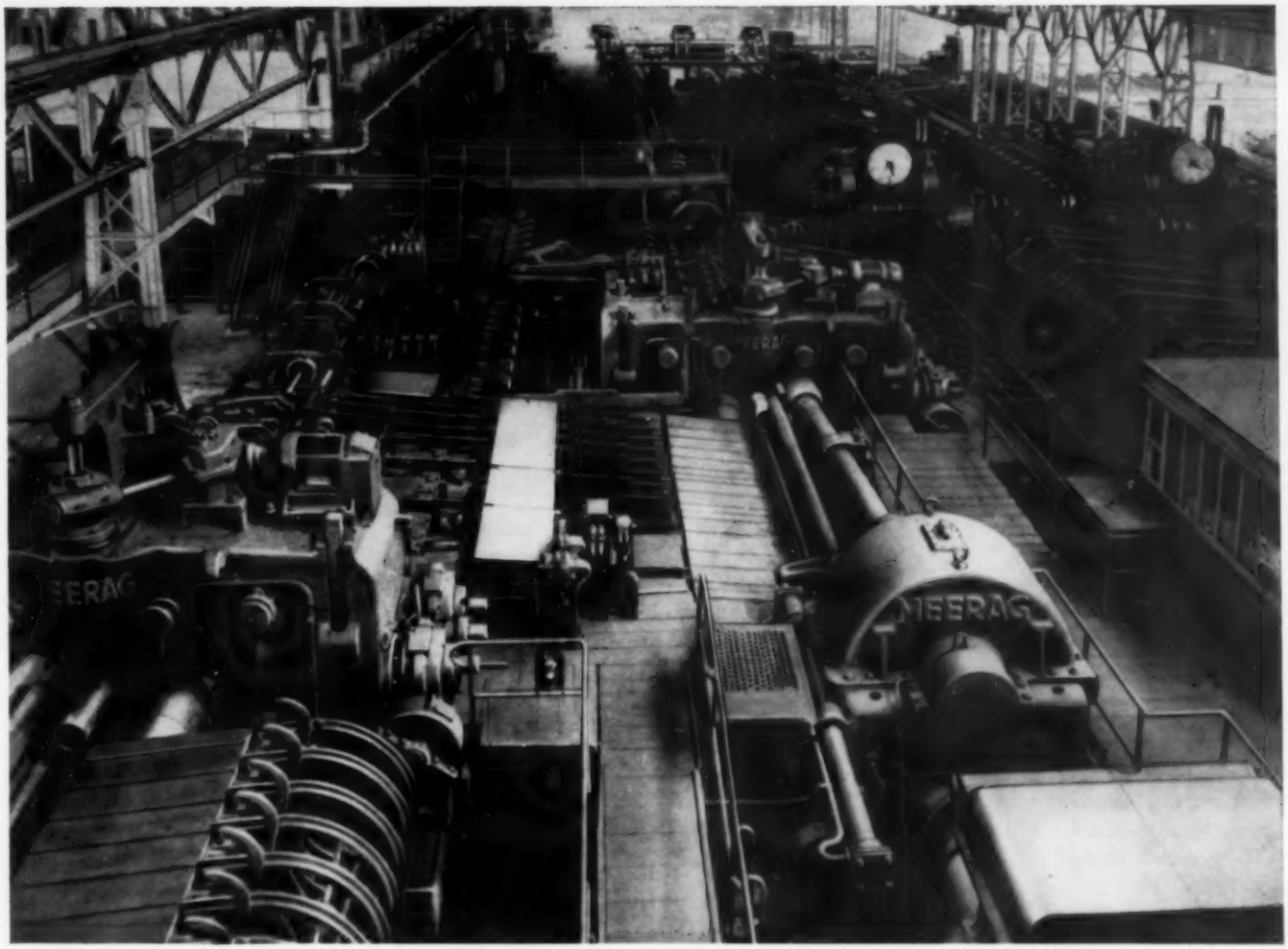
Patent No.	Date	Subject	Inventor or Assignee
2,658,390	11/10/53	Radiation pyrometer	Leeds and Northrup Co.
2,658,611	11/10/53	Wire drawing block and stripper assembly	The Vaughn Machinery Co.
2,658,633	11/10/53	Work conveyor for heat-treating furnaces	Holcroft & Co.
2,658,636	11/10/53	Method of controlling pressure between bells of blast furnaces	Arthur D. Little, Inc.
2,658,741	11/10/53	Rolling mill for rolling strips or bands and sheets of steel	Westfalenhutte Dortmund Aktiengesellschaft
2,658,862	11/10/53	Production of hard metallurgical coke from a preheated fluidized coal	Reilly Tar & Chemical Corp.
2,658,865	11/10/53	Coke oven doorframe	Ernst Wolff
2,659,120	11/17/53	Apparatus for separating slag from molten metal	The Babcock & Wilcox Co.
2,659,121	11/17/53	Pouring box for continuous casting machines	Continuous Metalcast Co., Inc.
2,659,326-7	11/17/53	Roof for tilting furnaces	Veitscher Magnesitwerke-Aktiengesellschaft
2,659,932	11/24/53	Apparatus for extruding insulating jacket around electric cable	United States Steel Corp.
2,660,321	11/24/53	Apparatus for removing slabs from heating furnaces	United States Steel Corp.
2,660,414	11/24/53	Electromagnetic vibrator apparatus for treating molten metals	Selas Corp. of America
2,660,419	11/24/53	Apparatus for introducing air to burners of reversing type furnaces	United States Steel Corp.
2,660,420	11/24/53	Annealing base construction	United States Steel Corp.
2,660,429	11/24/53	Apparatus for automatically centering strips on a roll	United States Steel Corp.
2,660,534	11/24/53	Blast furnace linings	Illinois Clay Products Co.
2,660,545	11/24/53	Method for forming centering cavities in billet ends	United States Steel Corp.
2,660,880	12/ 1/53	Apparatus for use in determining the ultimate tensile strength of steel under impact	Arthur C. Vivian
2,660,881	12/ 1/53	Creep testing of high-temperature alloys	General Motors Corp.
2,660,979	12/ 1/53	Apparatus for connecting metal coating rolls with a driving mechanism	United States Steel Corp.
2,661,009	12/ 1/53	Apparatus for pickling steel strip	General Electric Co.
2,661,198	12/ 1/53	Furnace end structure for open hearth	Inland Steel Co.
2,661,278	12/ 1/53	Production of pig iron	Emil Edwin
2,661,279	12/ 1/53	Ladle treatment for corrosion- and heat-resisting steels	Ebaloy, Inc.
2,661,281	12/ 1/53	Production of cast iron containing calcium	The British Cast Iron Research Assoc.
2,661,283	12/ 1/53	Lithium-treated cast iron	Meehanite Metal Corp.

A detailed example of the operating procedure is given in the patent specification.

METHOD OF FLOW-BRIGHTENING TINPLATE

In the high speed production of electrolytic tinplate, ferrous strip is continuously passed through a long and complicated electroplating line at 1000 fpm or more. As the strip passes through the line, it is electroplated with tin. The amount of tin deposited on the strip is relatively small when compared to tinplate produced by the hot dip process. The tinplate leaving the electroplating cell has a dull finish, so that it is normally washed and passed through suitable flow-brightening apparatus. As the strip moves through this apparatus, the tin coating is heated to a temperature above its melting point (449 F) so that the tin will flow and upon quenching will have a bright mirrorlike surface. Water is the most desirable quenching medium, but it tends to produce surface blemishes on the tinplate. One type of blemish is called "quench lines." This can be minimized by maintaining the quench water at 100 F or less. However, reducing the quench water temperature below 135 F tends to increase the occurrence of another type of surface blemish known as "snow balls."

In U. S. 2,661,328, issued Dec. 1, 1953 to Edwin J. Smith and assigned to National Steel Corp., these difficulties are overcome. As shown in Figure 5, the strip S, after leaving the electroplating apparatus, passes through rolls 10 and 11, down and



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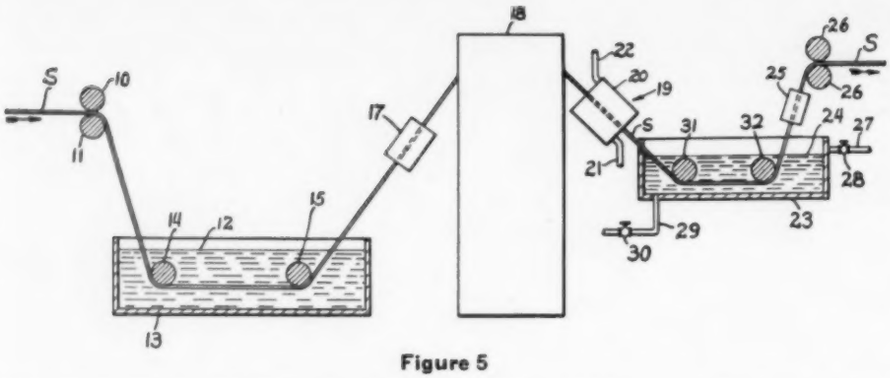


Figure 5

through an aqueous rinsing bath in tank 13. This bath removes any residual electroplating salts. Preferably the bath is heated so that the film of rinse water adhering to the strip will evaporate readily. The rinsed strip passes through a dryer 17 and through a flow-brightening furnace 18 in which the tin coating is heated above its fusion temperature. The strip then passes through a precooler 19, through which a non-oxidizing cooling gas flows in a direction countercurrent to the direction of strip travel. The molten tin is thus partly cooled without disturbing its surface. The strip then passes to a water quench tank 23 which effects solidification of the tin coating. The wet strip passes through a dryer 25, and through a pair of rolls 26 to a cooler. The temperature of the water flowing through the quench tank is maintained at 125-130 F.

It is claimed that the gas pre-cooling, followed by water quenching at 125-130 F eliminates quench lines without producing snow balls.

PIPE COOLING ARRANGEMENT FOR HIGH-SPEED CONTINUOUS MILLS

U.S. 2,658,257, issued Nov. 10, 1953 to Bryant Bannister and assigned to United States Steel Corp., relates to high speed continuous pipe mills and particularly to an improved arrangement for cooling and cutting the pipe to length.

In modern continuous pipe mills where the speed of delivery of pipe from the welding and sizing mill has reached speeds in excess of about 2000 fpm, the problem of cooling and cutting the sized pipe to length becomes acute. Heretofore, the pipe has been cut to salable lengths as it emerges from the sizing mill. This, however, is physically impossible at present day delivery speeds.

Figure 6 is a plan, Figure 7 a side elevation, and Figure 8 a wiring diagram of the invention. The numeral 2 designates a conveyor for delivering pipe in continuous lengths from a high speed mill (not shown). Pipe P on the delivery conveyor passes through a rotary shear S which cuts it into lengths which are multiples of the finished lengths desired, and these multiple lengths ML are then transferred by conveyor 4 and screws 6 to a cooling table 8. The cooling table consists of several endless chains 10 for moving the multiple lengths onto a conveyor 12, which then moves them to saws 14 where they are cut to the desired finished lengths FL.

In regular operation, the shear S is intermittently rotated one revolution by the shear motor 20 actuated by an automatic control 21. If there is a holdup on the conveyor 4 or cooling table 8, a separate control causes the pipe to be cut continually into short scrap lengths which are deflected from the conveyor 4 by a solenoid operated deflector gate 22 into a bucket 24.

Line L1 is connected directly to the solenoid 26 of the deflector, the automatic control 21 and contact a of a double pole knife switch 30. Line L2 is connected directly to the motor 20 and to contact d of the knife switch 30.

In case of trouble in the conveyor or cooling table beyond the shear, the mill operator can operate the switch 30 to close contacts a, b and c, d, whereby the controller 21 is bypassed and the motor 20 is continuously energized, thus cutting the pipe into short lengths. At the same time, the solenoid 26 is energized so that deflector 22 is moved into the

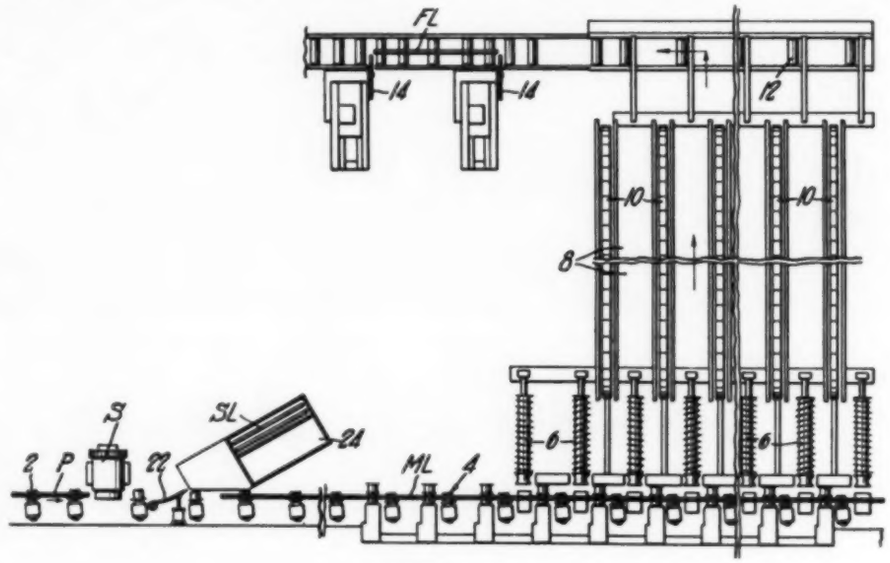


Figure 6

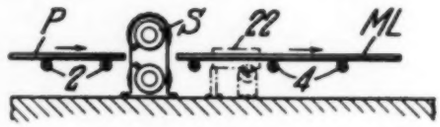
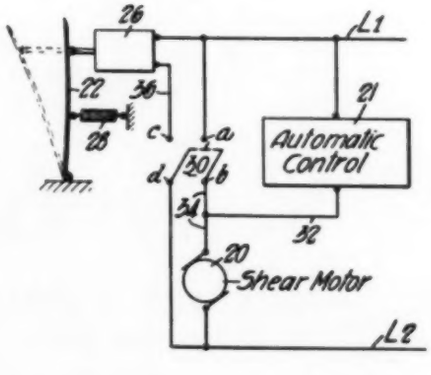


Figure 7

Figure 8



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pass line of the cut lengths to deflect them onto the bucket 24.

APPARATUS FOR CONVEYING STEEL SHEETS

In the manufacture of tinplate it is necessary to inspect the sheets either visually by an inspector or, in the case of inspecting for pin holes, automatically by means of an electric eye. In either case, the sheets are inspected as they pass along a conveyor and the defective sheets are later deflected from the conveyor line into a reject pile or piles. This deflection is ordinarily accomplished by means of a pivotally mounted flap gate, the operation of which is controlled by a synchronous timing device which is preset to open the flap gate just as the selected sheet arrives in front of it. The flap gates which are mechanically operated up and down must be relatively heavy and of special shape and construction to facilitate passage of the reject to the pile below the belt and also be designed so that they will be flat to permit easy passage of the prime sheets over them. The flap gate, because of its relatively heavy weight has awkward mechanical and moving parts which wear and cause trouble. Its operation is slow, so that it is unsuitable for high speed production.

In U.S. 2,660,318, issued Nov. 24, 1953 to Coleman H. Watson and assigned to United States Steel Corp., a sheet diverter is described which has no moving parts to start and stop for each operation. The apparatus is shown in Figures 9, 10, and 11, in increasing detail.

The numeral 2 represents a belt conveyor over which a sheet S is passing. Spaced from the conveyor 2 is a second conveyor 4 which normally receives the sheet S from the conveyor 2. A stationary deflector 6 is arranged between these conveyors. A magnetizable roller 8 is arranged between the delivery end of conveyor 2 and the deflector 6. The roll 8 is provided with a shaft 10 to which is rigidly attached an electromagnet 12.

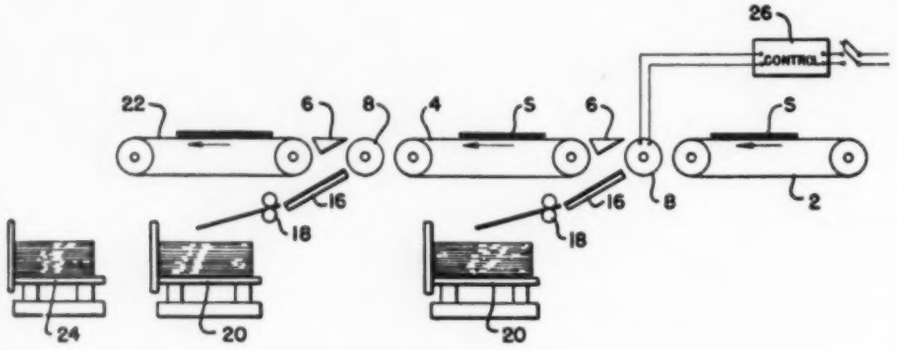


Figure 9

The roll is mounted for rotation about the shaft, and may be driven independently or from the conveyor roll as shown in Figure 11. Extending downward at an angle is a guide 16 which leads to a pair of driven pinch rolls 18, followed by a reject piler 20. If it is desired to have three classifications of sheets, a third conveyor 22 is arranged in a line with the rest of the apparatus in a similar way.

The electromagnet 12 is selectively magnetized and demagnetized by a control 26, which may be started in operation either manually or automatically, depending on the type of inspection.

When the sheet S is found to be defective, the control 26 operates to magnetize the electromagnet just as the sheet is approaching it. This causes the sheet to be diverted downward along the guide 16 to the pinch rolls 18, and hence to the reject piler 20. As soon as the sheet S passes from the roll 8, the control 26 demagnetizes the electromagnet. Hence any sheets fed along conveyor 2 will continue along conveyors 4 and 22 to the prime piler 24. For high speed operation, it is desirable to rotate the roll 8 at a greater peripheral speed than the speed of conveyor 2 so that the sheet S will be moved out of the way of succeeding sheets.

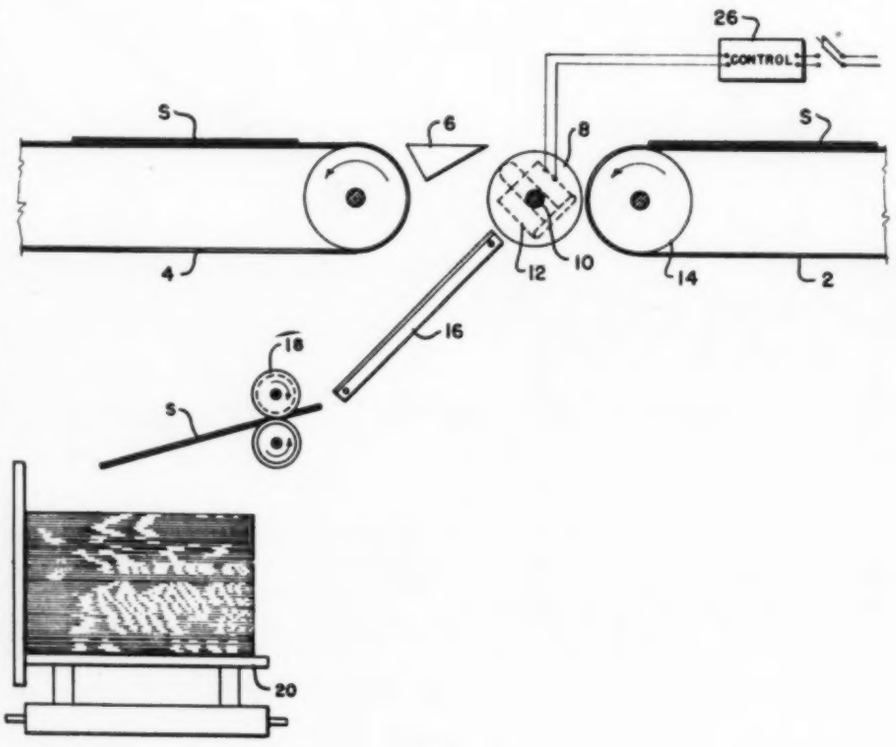
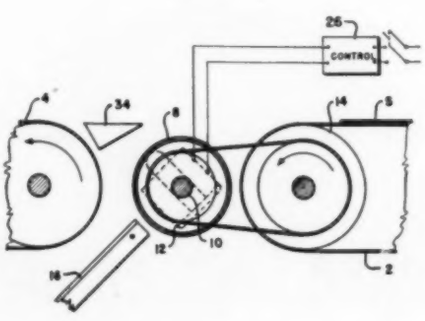


Figure 10

Figure 11



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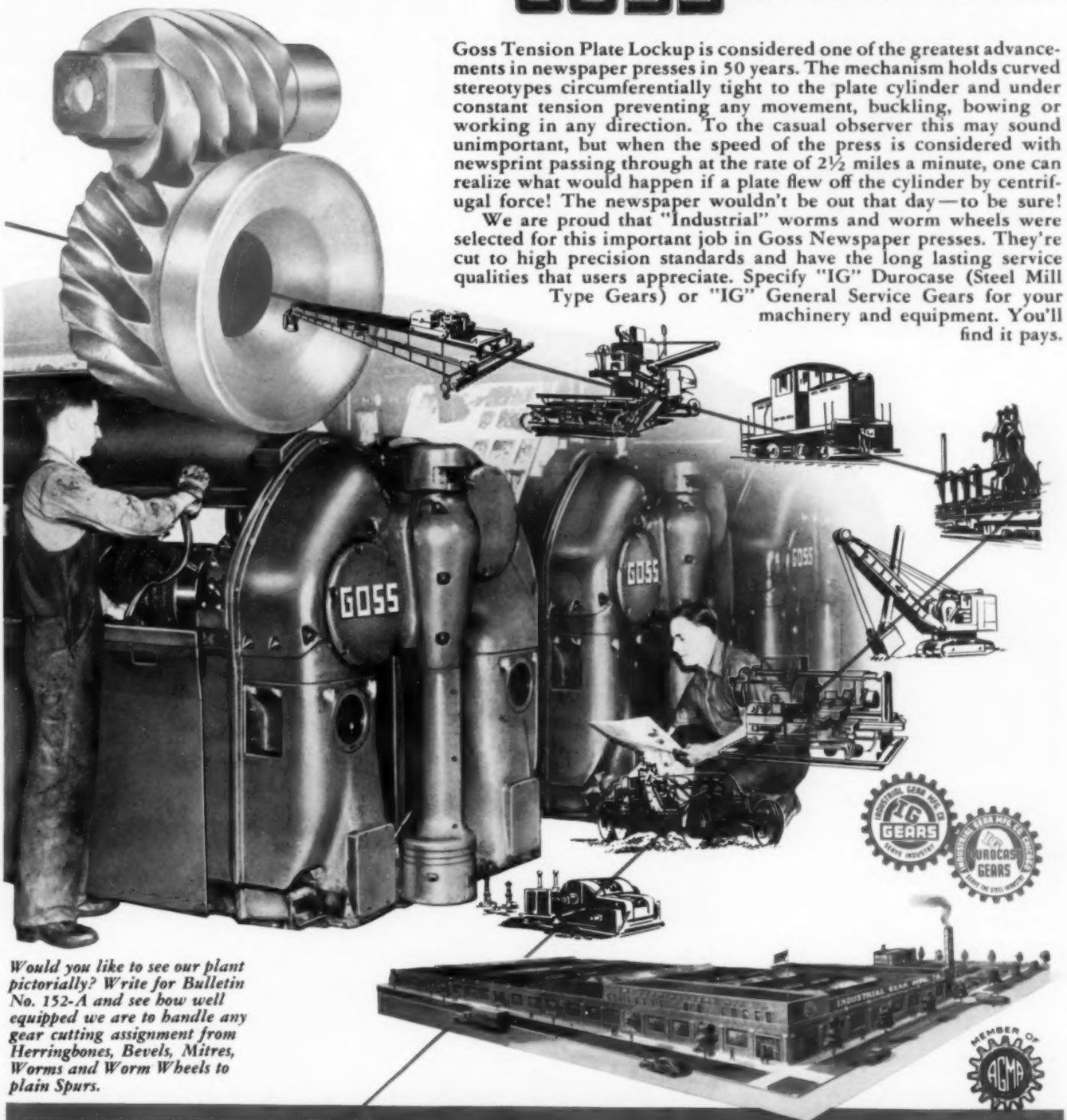

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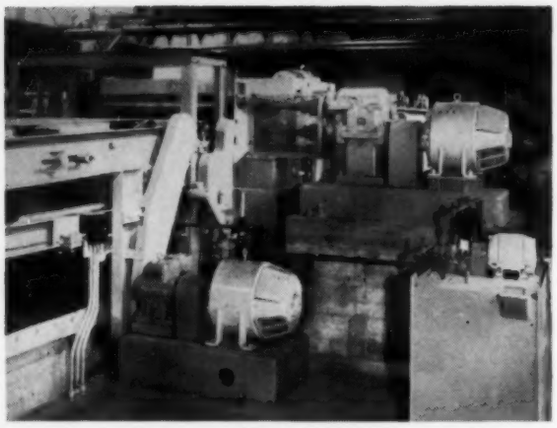
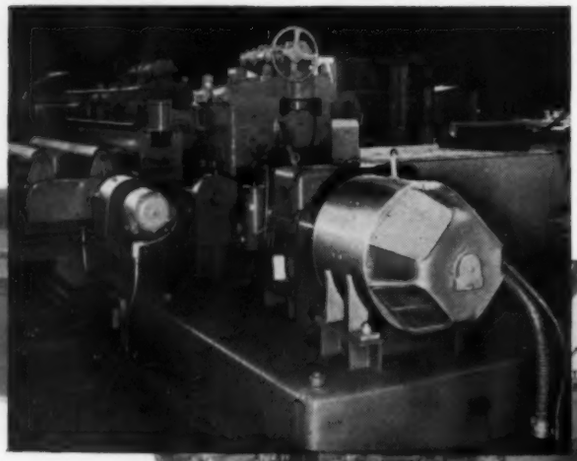
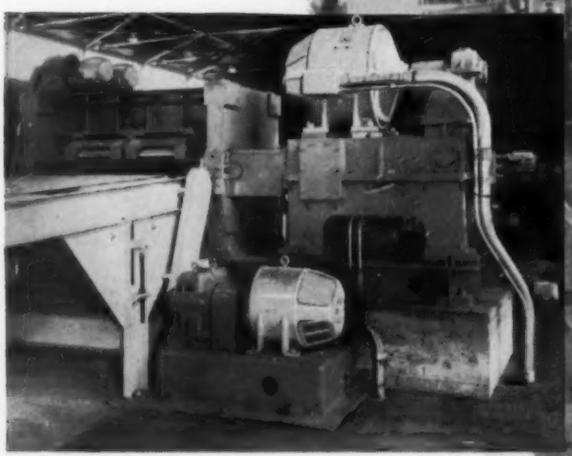


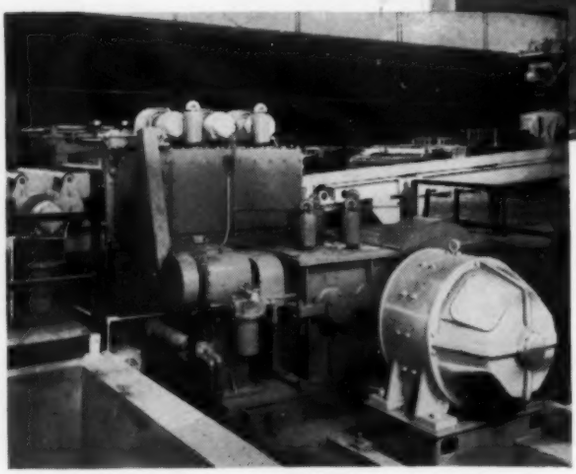
A 20-hp d-c motor, at right, drives the oil machine and pinch roll on the reject piler. Below, main drive for the belt conveyor, also a small a-c motor on an oil pump. All these are Elliott C-W motors.

The Elliott Crocker-Wheeler 40-hp, 850/1700-rpm d-c motor that drives the side trimmer in the shear line. At the left, an Elliott C-W 2-hp induction motor serving side guide adjustment.

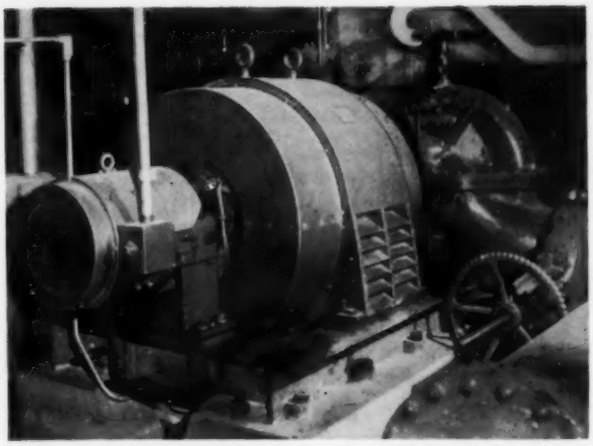




The leveller in the shear line is driven by the Elliott C-W 100-hp, 850/1500-rpm d-c motor shown at top. At bottom, a 15-hp motor drives the belt conveyor, and at top left, two 2-hp motors drive the roll adjustment.

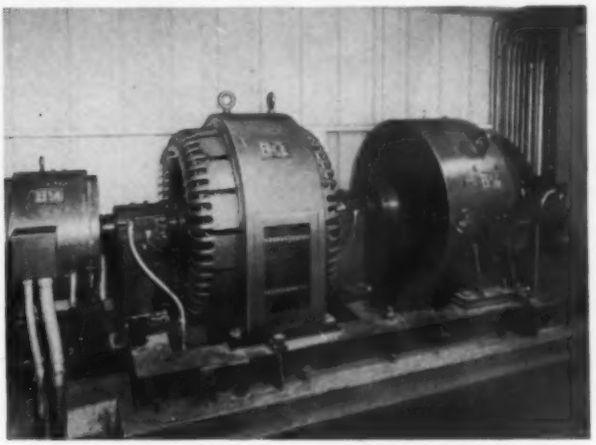


The Hallden shear and its main drive—an Elliott C-W 150-hp, 690/1200-rpm, dripproof, protected d-c motor. Also shown are three 2-hp and one 5-hp squirrel-cage motors on secondary drives.



An Elliott 1500-hp, 900-rpm, .8-pf, 6900-v dripproof synchronous motor with direct-connected exciter. This one drives one of the two large water pumps. Another pump is driven by an Elliott steam turbine.

Power for the shear line is supplied by this Elliott motor-generator, a 450-kw, 1200-rpm d-c generator with 25-kw exciter, driven by a 700-hp synchronous motor.



How ELLIOTT motors serve Pittsburgh Steel's expanded facilities

One of the major expansion projects of Pittsburgh Steel's Program of Progress is the new facilities in the Allenport Works, located 25 miles south of Pittsburgh. Among the important new installations in this mill are the hot shear line and a new water pumping plant. Elliott motors, ranging from 1 hp to 1500 hp, provide a number of main and secondary drives in both of these new additions. As the photos on these two pages indicate, a variety of Elliott motors are serving in this mill, as they are in others throughout the steel industry. Full details on the line are available at any Elliott District Office or from Elliott Company, Jeannette, Pa.

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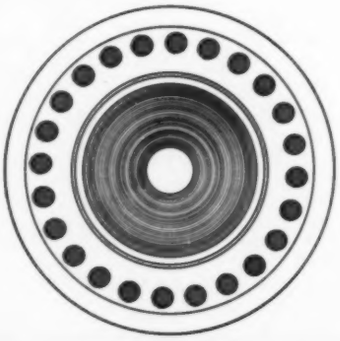
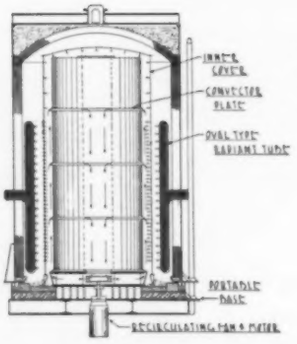
Compact design of "O" tube permits complete blanketing of inner cover



Note how charge receives heat equally from all sides

Design presents maximum heating surface for quicker heating



The entire portion of the tube is inside the furnace No lost-heat

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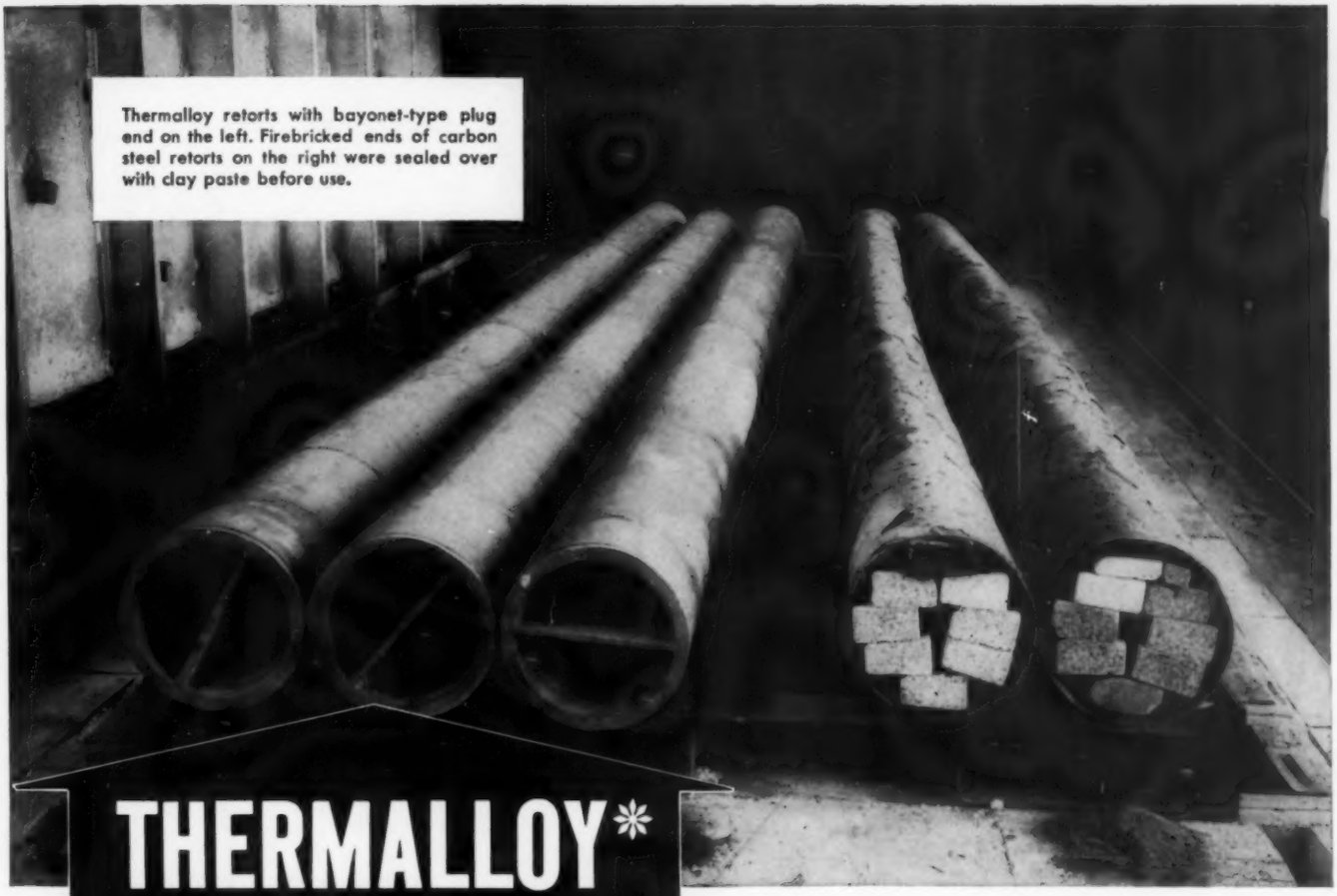

Thermalloy retorts with bayonet-type plug end on the left. Firebricked ends of carbon steel retorts on the right were sealed over with clay paste before use.

THERMALLOY*

outlasts carbon steel retorts . . . 28 to 1

In a plant of a large eastern tool and specialty steel manufacturer, long, pipe-like retorts are used to anneal and heat-treat high-speed carbon and alloy steel bar stock in hood-type furnace equipment. Temperatures range up to 1650°F. during the annealing or heat-treating cycle that may last 30 hours.

Under these conditions, this manufacturer found that wrought carbon steel retorts scaled excessively and also distorted and flattened during operation . . . limiting service life to about 500 cycle hours. For the same operation, centrifugally cast Thermalloy retorts showed no measurable scale loss and maintained uniform wall thickness and shape. When last reported, Thermalloy retorts had been operating over 14,000 cycle hours and were still in perfect condition.

As the wrought carbon steel retorts became distorted, the plugs necessary to seal the open ends would not fit. Firebrick and a clay paste were used to seal the ends against infiltration of furnace gases. This made uniform annealing or heat-treating practically impossible. However, Thermalloy retorts, with plug ends designed by Electro-Alloys, afforded practically gas-tight seals and much greater ease of handling.

Today, this manufacturer is replacing all of the wrought carbon steel retorts with high heat-resistant Thermalloy retorts. Perhaps the same operating economy may interest you in Thermalloy retorts, furnace parts, trays, racks, pots or muffles. For full information, call in an Electro-Alloys engineer or write Electro-Alloys Division, 5006 Taylor Street, Elyria, Ohio.

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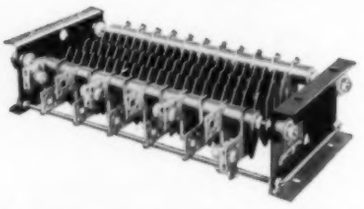
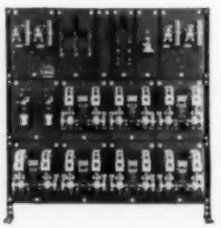


Tab-Weld Plate Resistors feature spot-welding that provides a continuous path and keeps resistance value constant.



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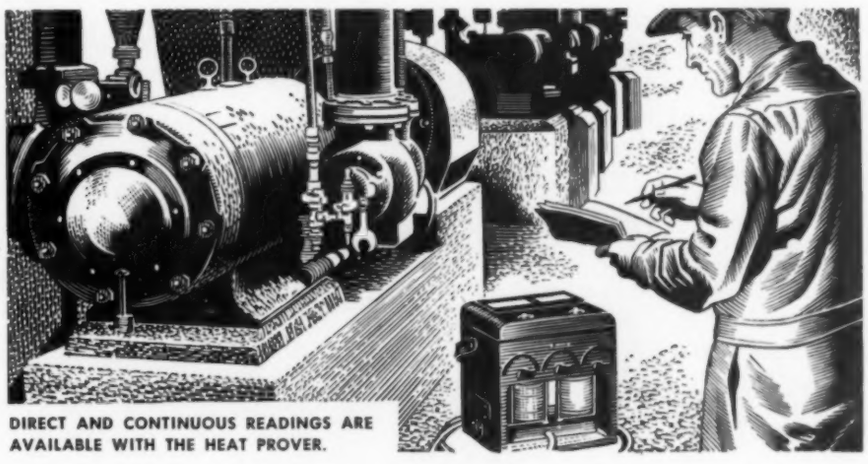

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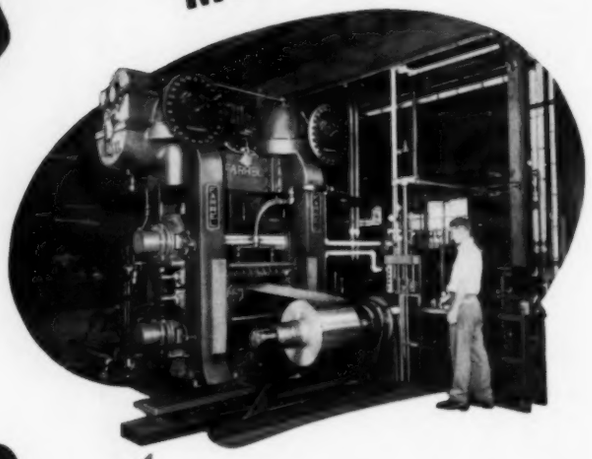
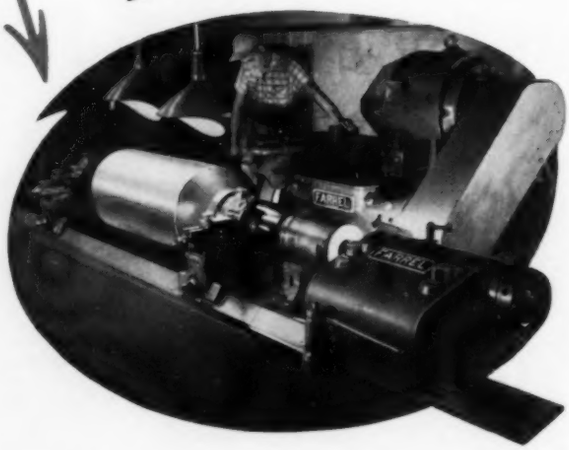


MILL DRIVES

ROLL GRINDERS



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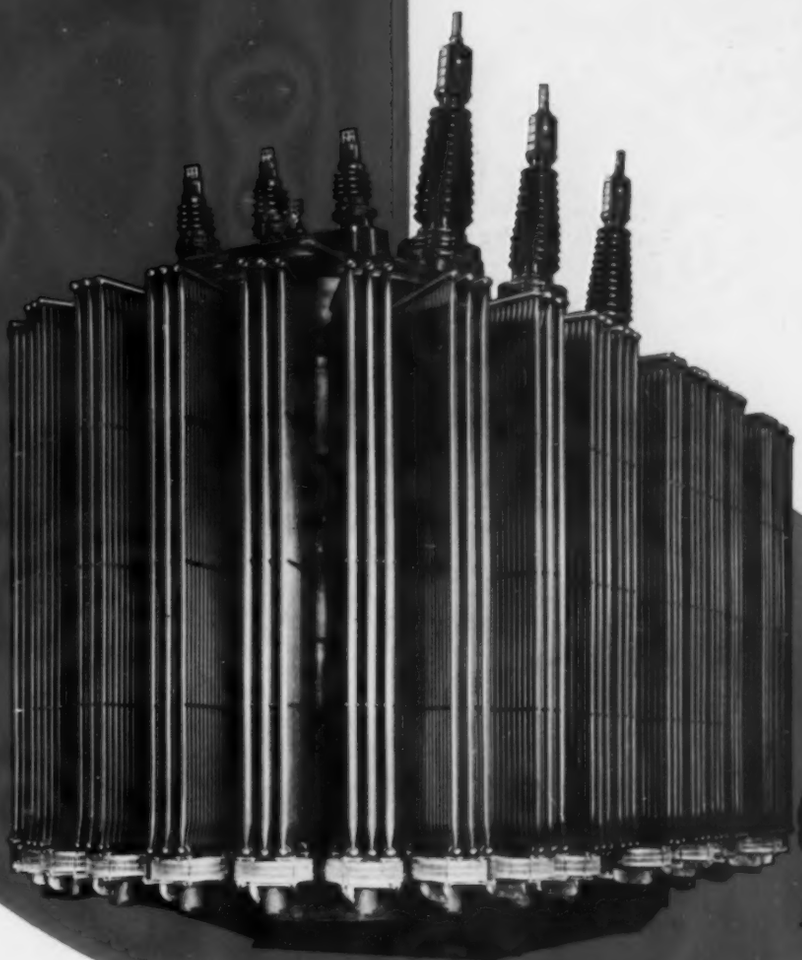

This three-winding auto transformer has a forced-air-cooled rating of 60,000 Kva and a self-cooled rating of 48,000 Kva. It is designed to take the full capacity of the generator on the 13,200 volt delta tertiary winding and step up the voltage to either 132,000 volts or 67,200 volts, or to both simultaneously. If the generator is out of service, the transformer permits full capacity transfer between the 132,000 volt and 67,200 volt systems through the auto connection in the high voltage winding.

PENNSYLVANIA
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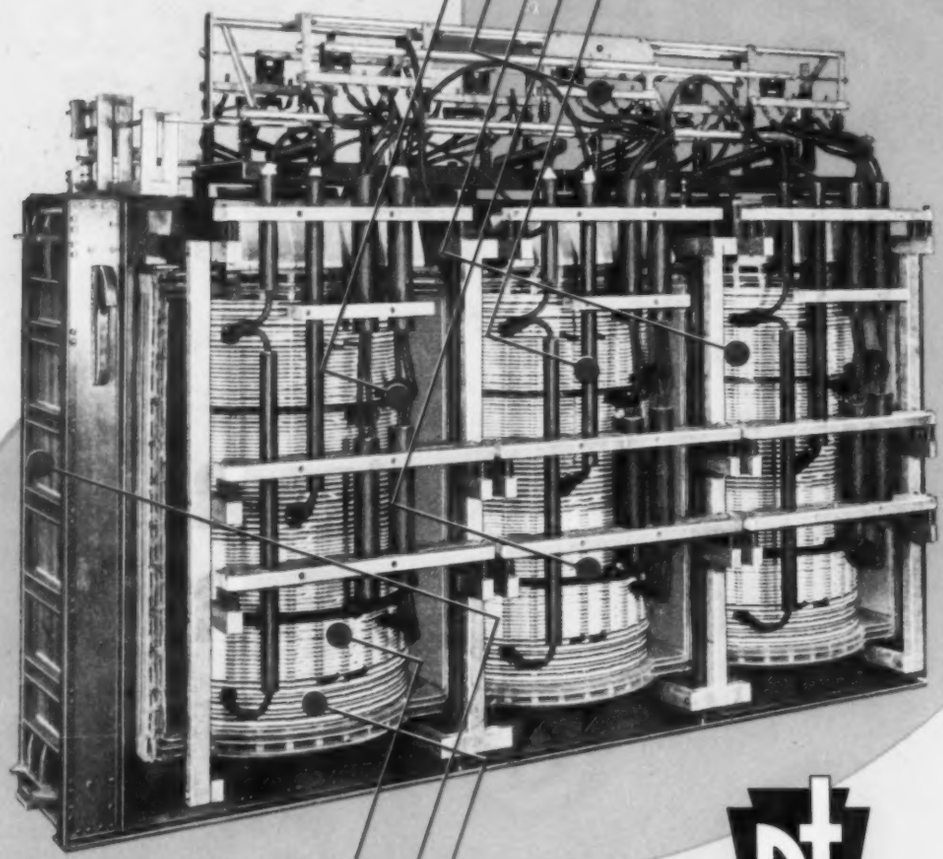
Tap changer located above core and coils for easy access through cover of transformer.

Continuous pancake winding in High and Low Voltage coils. Helical winding in Tertiary coils.

Taps are located in the High Voltage windings (132,000 volts) as well as the Low Voltage windings (67,200 volts).

All leads are well supported and insulated in heavy pressboard tubes.



Coils are precompressed with a force equal to the highest short circuit stress and built into transformer at that compressed dimension. This prevents mechanical distortion of the coils if short circuit stresses occur.

Five-legged core reduces shipping height.

Extra heavy insulation at line ends of coils. Graded insulation at ground ends of coils.

60,000 Kva forced-air-cooled/48,000 Kva self-cooled. Three phase, 60 Cycles, 55°C. Temperature rise. High Voltage: 132,000 Grd. Y. volts. Low Voltage: 67,200 Grd. Y volts. Tertiary Voltage: 13,200 Delta volts.

Weight of complete transformer filled with oil — 356,700 pounds.

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For exterior view of this transformer, see other side.

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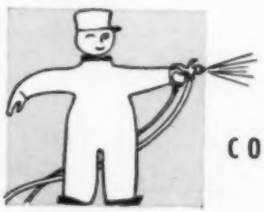

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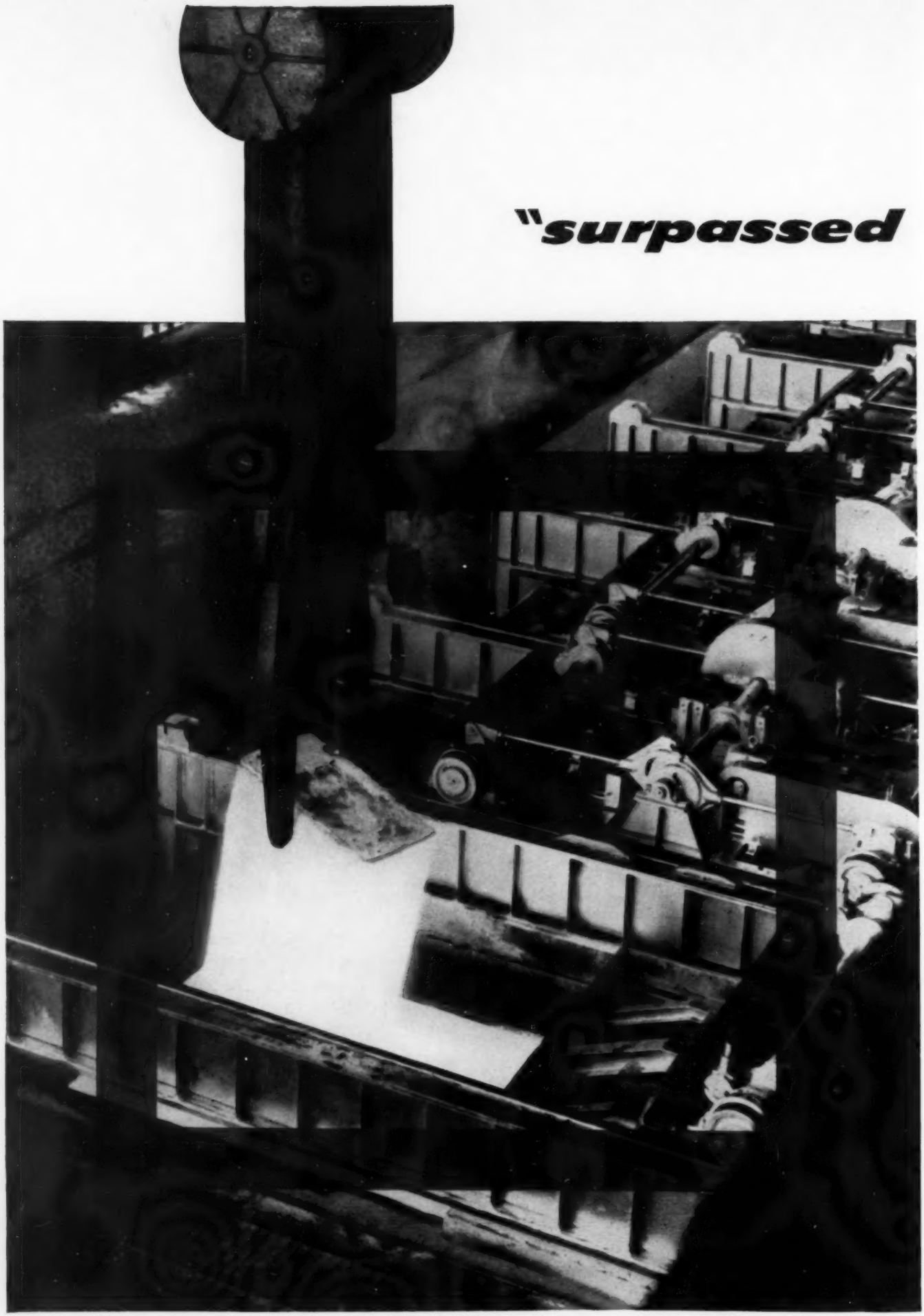
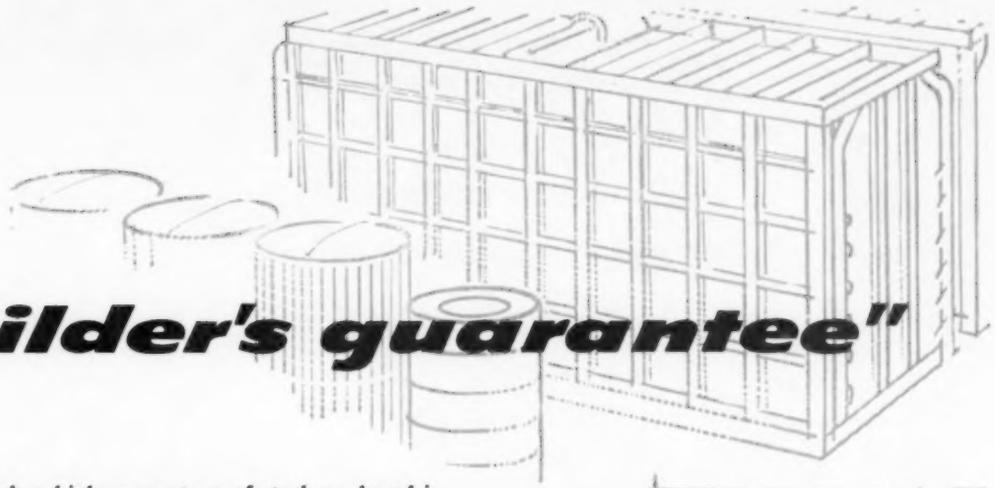
Representatives in Principal Cities


"surpassed



the builder's guarantee"

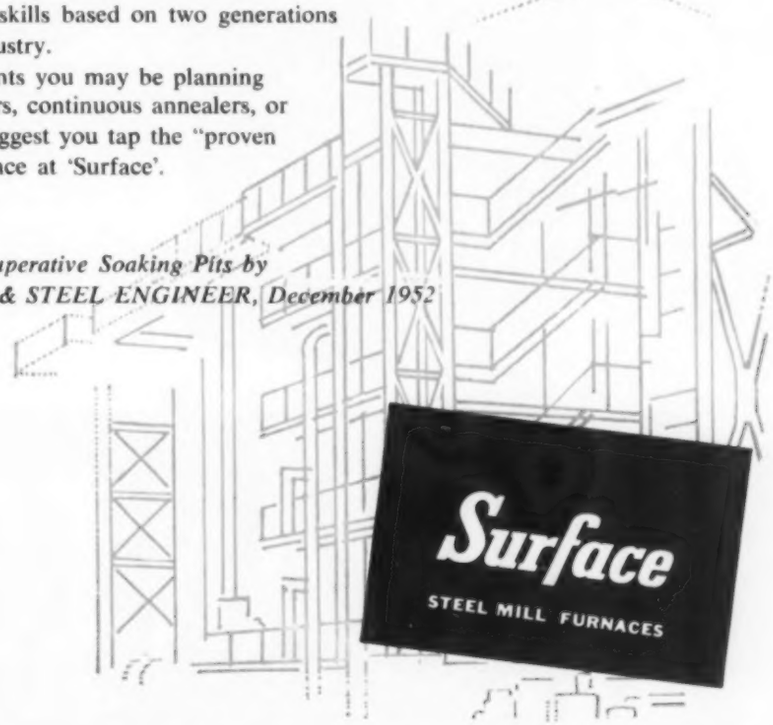
Why is it that such a high percentage of steel produced in this country passes through Surface Combustion equipment in one or more stages of its processing? Part of the answer might be furnished by a list of steel making advances in which our engineers have participated. The one-way fired soaking pit . . . the remotely located single recuperator serving a number of holes . . . the research which led to substantial increase in pit sizes without sacrificing the simplicity of the one-way firing principle . . . the jet pump which facilitates handling heated air in high volumes with low equipment maintenance . . . these you may recall as developments to which 'Surface' engineers contributed.

There's a more basic answer however: typically expressed in a customer's published report of comparatively recent 'Surface' soaking pit installation: "tons per hour . . . and fuel savings as shown by Btu ton figures . . . has *surpassed the builder's guarantee.*"

This business of making one's word good is by no means unique at 'Surface'. We like to believe however that we combine this old-fashioned way of doing business with an exceptionally effective combination of metallurgical and construction skills based on two generations of experience and growth with the steel industry.

Whatever long-range capital investments you may be planning in soaking pits, slab heaters, annealing covers, continuous annealers, or any equipment involving combustion, we suggest you tap the "proven resources" of cost-saving skills and experience at 'Surface'.

"Operative Results of One-Way Fired Recuperative Soaking Pits by E. H. Cauger and J. C. Stamm, Jr., IRON & STEEL ENGINEER, December 1952



SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

One-way fired soaking pits • Billet reheating furnaces • Slab heating furnaces • Continuous type, controlled atmosphere strip annealing and normalizing furnaces • Controlled atmosphere annealing covers for wire and rod • Controlled atmosphere annealing covers for coil and sheets • Continuous furnaces for heat treatment of steel plate • Controlled atmosphere furnaces for carbon correction in high alloy rod and bar stock • Continuous type bright annealing and normalizing furnaces • Prepared gas atmosphere generating equipment • Pit type convection furnaces for rod annealing • Stress relief furnaces • Wire patenting furnaces

Oil Immersed

mechanically interlocked power outlet

Type 620-A3GX Safety Switch with Receptacle and Plug Interlock — Closed view and with oil tank lowered showing arrangement of component Parts.

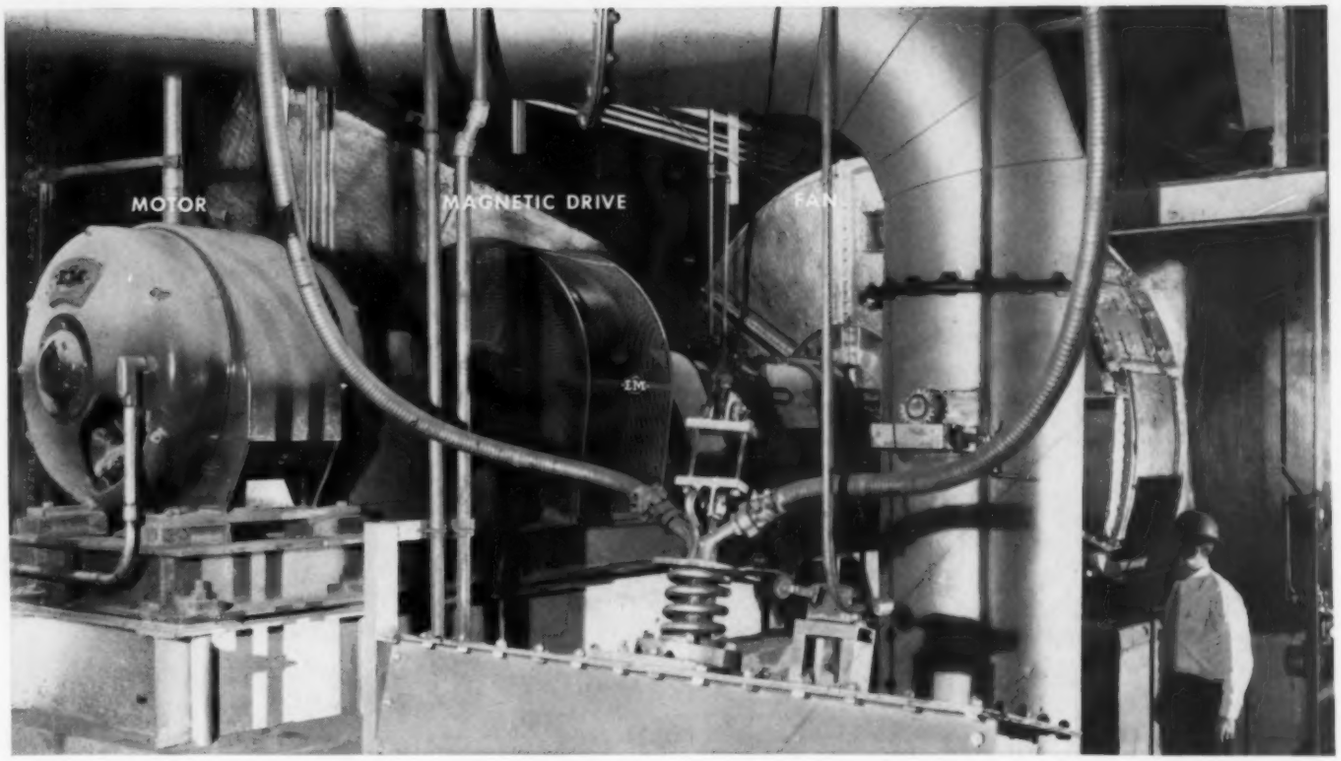
A SAFETY POWER outlet to provide dependable operation under adverse conditions and convenience for readily connecting portable equipment such as welding machinery, conveyors, mixers, agitators, etc. Manually operated, mechanically interlocked switch handle and plug makes it impossible to insert or remove the plug while the switch is in the closed position.

Standard features of the Rowan Type 620-A-3GX Safety Switch include the following: completely oil immersed; manually operated disconnect switch of the quick-acting contactor type with renewable contacts; equipped with ROWAN time-tested AIR-SEAL fuses; sealed-off terminal compartment; safety disconnect jack; straight through conduit entrance; provision for padlocking switch in the OFF position; enclosure designed to meet the requirements of NEMA Type XI — also available for NEMA Type VIII, Class 1, Group D locations, designated Type 620-A-1-3GX.

Complete information available from Rowan representative in principal cities of the United States.

ROWAN CONTROL

THE ROWAN CONTROLLER CO., BALTIMORE, MD.



A waste-heat boiler induced draft fan in a large steel mill receives driving power and precise speed control from a 200 hp, 720 rpm E-M Synchronous Motor and a 200 hp, 350/705 rpm EM Adjustable-Speed Magnetic Drive.

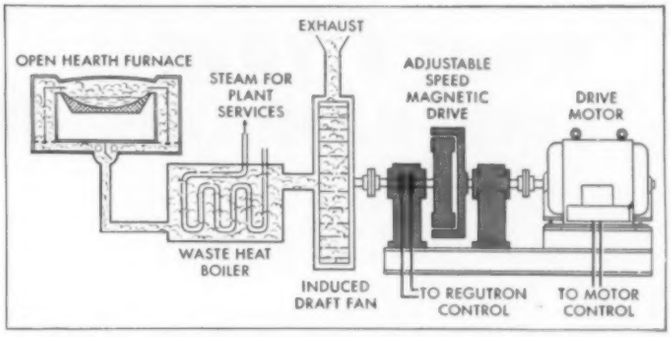
How to reduce erosion of waste-heat boiler induced draft fans

Many modern steel plants now use waste heat from banks of open hearth furnaces to produce steam for plant services. An induced draft fan draws waste gas through a waste-heat boiler to recover heat from open-hearth gases usually exhausted out a stack.

Speed control of this fan is essential for economical operation, and the E-M Adjustable-Speed Magnetic Drive is the best answer to this need. It transmits torque electromagnetically from the constant speed drive motor to the fan, responding automatically and precisely when speed changes are signalled. This Drive, with the sensitive E-M Regutron Control, provides *true* speed control regardless of variations in operating conditions.

Sizable reductions in fan blade erosion are achieved, as the fan is not required to run constantly at full speed against the highly abrasive gases when reduced output is wanted. The Magnetic Drive is equally effective and economical in drawing cool air through the boilers during shut-down for boiler maintenance or repair.

See how this Drive can save costs and increase over-all efficiency in your plant. Ask your nearest E-M sales engineer for details, and write for E-M Publication No. 1107 on Magnetic Drives.



Here, in a simplified diagram, is how the E-M Adjustable-Speed Magnetic Drive fits into the Waste-Heat Boiler system, providing precise, automatic control of the induced draft fan.

ELECTRIC MACHINERY MFG. COMPANY
MINNEAPOLIS 13, MINNESOTA

E-M

4400-TPA-2145

Magnetic Drives make draft fans do
EXACTLY WHAT YOU WANT THEM TO

WHAT'S YOUR BULK-HANDLING HEADACHE?

Get in touch with R&S——

Coal? Coke? Coke breeze? Sand? Dolomite? Something else? Whatever your headache material may be, it's more than likely we can help you engineer a simple, effective, low-cost way to handle it. We've been solving just such problems for more than 50 years — for big companies and small . . . companies with overworked engineering staffs to those with no engineers at all.

R&S engineers can start "from scratch" or can use your preliminary plans. They can develop rough sketches into finished drawings, convert finished drawings into fabricated units — and then follow tnrough on erection if desired: the whole job or any part of it. Any time you're ready. What's *your* problem?

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NEW YORK 19, N. Y.
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R&S AND COMPANY

Colorado Fuel and Iron open hearth being resurfaced with Permanente 165 Ramming Mix. It's one of the many refractory materials we regularly supply to C F & I.

INCREASE YOUR OPEN HEARTH PRODUCTION

WITH PERMANENTE 165 RAMMING MIX!

THE UNBEATABLE combination of Permanente Ramming Mixes and Permanente Basic Bricks provides *superior* open hearth performance for many of the country's leading steel mills.

This combination results in lower cost per heat . . . gives a better bottom with added protection from tap hole to pan. This makes it possible for furnaces to break production records, with extra tonnage every hour.

Permanente Ramming Mixes combined with Permanente Basic Bricks can boost *your* open hearth production well above current rates.

Send for booklet giving *all* the important advantages of (1) Permanente 165, (2) the companion material, Permanente 84 and (3) Permanente Refractory Brick. Upon request, your Kaiser refractory engineer will promptly offer you research, design and installation service to help you obtain more steel tonnage per year, at lower bottom cost per ton. Call or write principal sales offices: *Chemical Division*, Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California. First National Tower, Akron 8, Ohio.

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Pioneers in Modern Basic Refractories

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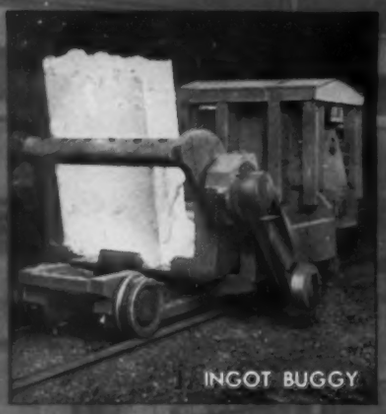


INGOT BUGGY

From 6-ton ingot... to fine and true gage strip, in a straight line from one original heat!

BLISS-BUILT hot mill for Empire Steel combines new and rebuilt equipment to save time and investment

Engineering a complete hot strip mill is no minor assignment at best. But when higher production goals must be reached, partially with existing machinery, the assignment becomes a real challenge.

In all, 30 complex units (mills and auxiliary equipment) were involved. Empire established the requirements, budget and time table. Existing machinery would be used as much as possible, but *rebuilt*, *repowered* and *modernized*. Completely new mills and accessories were to be added for certain vital operations. These were the requirements presented to Bliss—*who engineered the entire project.*

This highlight picture sequence gives some idea of the project's scope. The new objective called for transforming 6-ton ingots into hot rolled strip of fine tolerance... in a straight line and from the original heat! And the strip production had to yield sheet stock which, through subsequent finishing operations, would meet the trade's exacting specifications. This demanded Empire-Bliss teamwork, comprehensive field research, creative engineering at the site and at home, and unusual resourcefulness on the part of Bliss engineers.

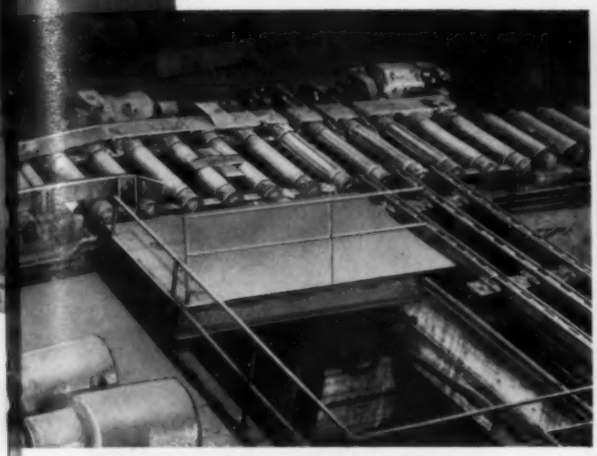
In production now, Empire's new hot strip mill has met every test successfully. Quality and output have reached anticipated goals. But this is just one example of Bliss' ability to supply the special skills, knowledge and service to meet specific requirements. Next time you have a rolling mill problem, talk it over with a Bliss engineer. The chances are good that Bliss will supply the best practical solution.

E. W. Bliss Company • General Office: Canton, Ohio

ROLLING MILL DIVISION: SALEM, OHIO

E. W. Bliss (England) Ltd., Derby, England • E. W. Bliss Co. (Paris), St. Ouen sur Seine, France

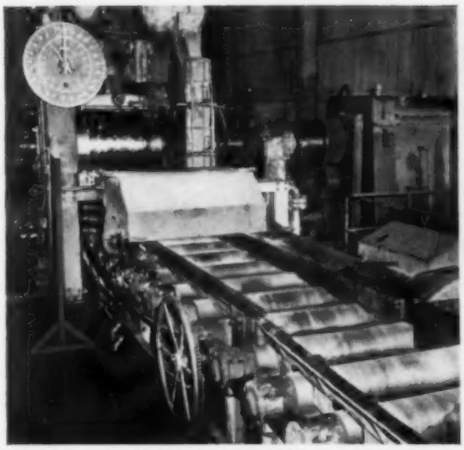
U. S. Plants in Canton, Salem, Toledo, Ohio; Hastings, Michigan. *Branch Offices* in Chicago, Cleveland, Dayton, Detroit, Indianapolis, New Haven, New York, Philadelphia, Rochester, Toledo; and Toronto, Canada. *West Coast Representatives:* Moore Machinery Co., Los Angeles and San Francisco; Star Machinery Co., Seattle. *Other representatives throughout the world.*



2. INGOT CROSS TRANSFER AND APPROACH TABLE

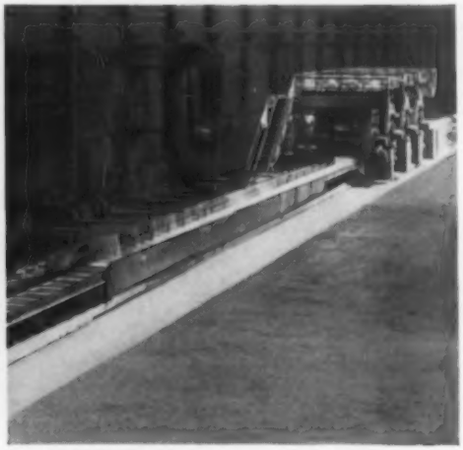
3. BLOOMING MILL—Revamped; supplemented with heavy mill tables

4. EDGING STAND of 1500 HP—designed new and to complement existing bloomer

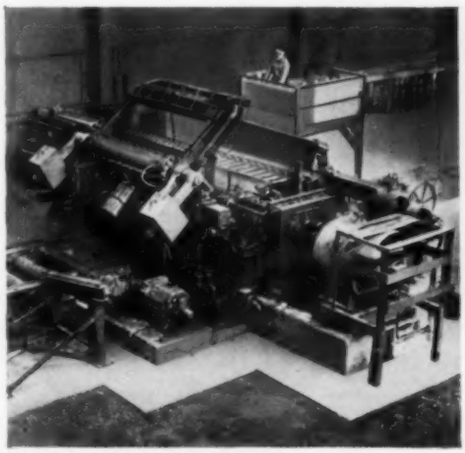


5. INTERMEDIATE ROUGHER—Modernized

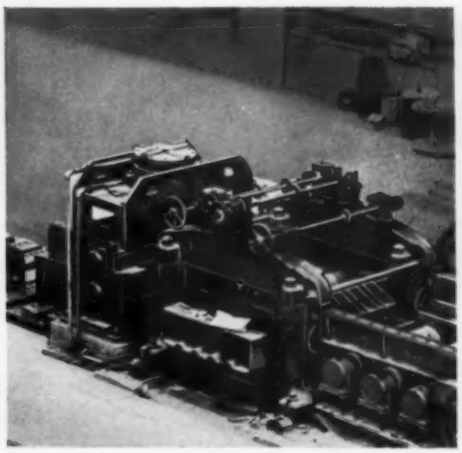
6. FOUR-STAND FINISHING TRAIN—Delivery end



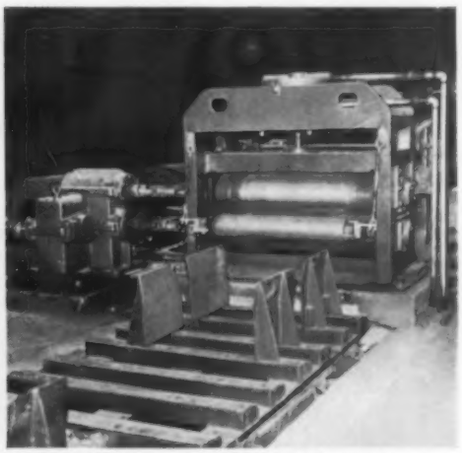
7. RUNOUT TABLE to upcoiler and shear line



8. HOT STRIP COILER—Revamped



9. HEAVY-DUTY ROLLER LEVELER AND SHEAR

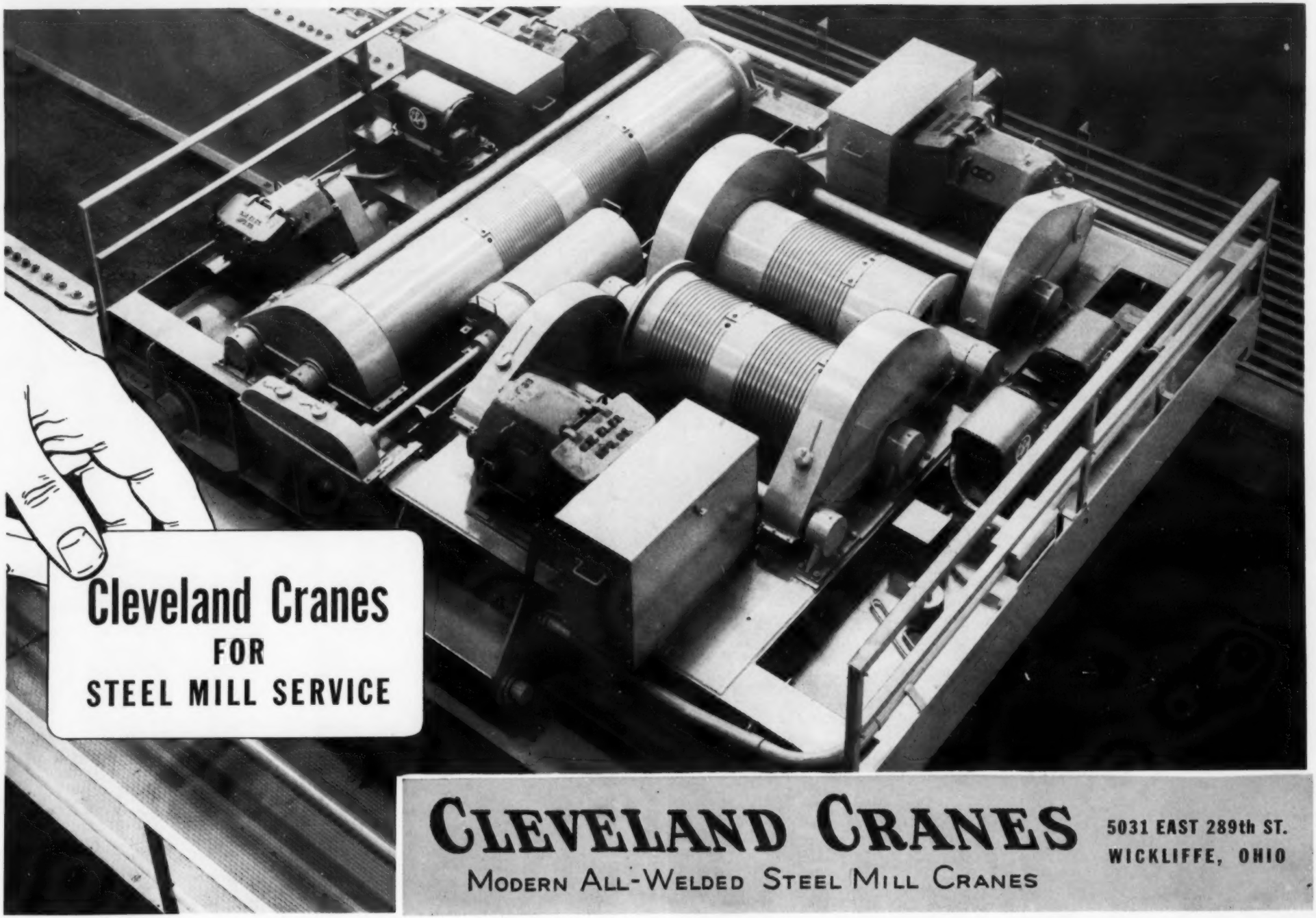


10. TERMINAL POINT OF LINE—Finish leveler and plate piler

Want a practical solution to your rolling mill problems? Do as Empire Steel Corporation did. Ask Bliss to show you how you can combine your available resources with new machinery to realize new production objectives. It can save you time and money, too.

Write today for your copy of Bliss' revised Rolling Mill Brochure. Ask for Bulletin 40-A.

Remember: BLISS **for Presses, ROLLING MILLS and Special Machinery**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FOR
STEEL MILL SERVICE
CLEVELAND CRANES
MODERN ALL-WELDED STEEL MILL CRANES
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Crops *and* Shorts

WITH wonderful cooperation and enthusiasm of members from both West and East, the first AISE western meeting was highly successful. Some 450 men heard a technical program presented by a fine array of authors. The new Hotel Statler in Los Angeles provided excellent facilities for meeting, greeting, eating and living. Kaiser Steel Corp. staged an interesting inspection trip through its Fontana plant.

Attendance included approximately 115 men from east of the Mississippi River, 205 from the Los Angeles area and 130 from western areas other than Los Angeles — not to mention some 25 or 30 wives who came along.

Our thanks to every one who helped to make this western venture such a success — and it looks as if we'll be back, perhaps in San Francisco, about a year from now.

▲

A correspondent sends us this gem:

"I need some help with my income tax.
That's why I've been delaying it.
Not in filling out the form,
But rather, more in paying it."

▲

FIGURES released by the American Iron and Steel Institute show the annual steel capacity of the United States to be made up of 109,095,000 tons open hearth, 4,787,000 tons bessemer, and 10,448,000 tons electric furnace.

▲

SOME quotes from the current press:

"1954 holds good prospects for a generally high level of employment" — Eugene G. Grace.

". . . a bright future for the country's construction industry" — C. F. Hood.

". . . backlog and expected new business indicate satisfactory operations for 1954" — Lorenz Iversen.

"Stock market strength indicates confidence in the financial picture."

"Bond markets strong."

"Current unemployment of 2,500,000 is about 60 per cent of what used to be considered normal."

"Individual earnings during January were at a rate of $282,500,000,000 a year, $2,000,000,000 under December but $2,000,000,000 above January, 1953" — U. S. Dept. of Commerce.

As we've said before, it's still good business.

THE charging of 76 tons of fine radioactive iron ore into a blast furnace at Ford Motor Co. indicated that about 40 per cent of the fine ore was carried out of the furnace in the gas.

▲

IN 1953, close to $8,000,000,000 were spent for advertising to sell the nation $210,000,000,000 worth of goods and services. That's about 4 per cent.

▲

COMMENTING on the recent report of the Randall Commission on Foreign Economic Policy, Koppers Co., Inc., is distributing a statement on tariff policy concluding thus:

". . . Koppers believes that tariffs should not be abolished as a matter of national policy. There should, however, be a selective policy of tariff treatment to provide protection for industries needed for national security. There should also be new selective tariffs or increases in existing tariffs as needed to offset cheap labor and subsidies, and to prevent dumping practices. These selective policies should not be patched-up adjustments of existing regulations, but should be those found to be specifically needed after thorough and intensive analyses of individual industries and their importance to our national well-being.

"The proper goal of international trade policies is the healthy encouragement of the world market; not the re-slicing of the American pie to the detriment of our national security and at the expense of United States citizens and industries."

▲

THEY say that old age isn't the period when a fellow stops looking at good looking girls, it's when all the girls look good to him.

If that's true, some fellows we know are older than we thought.

▲

AN item in Allis-Chalmers' Annual Review of Engineering Developments states that the steel industry has been spending nearly $1500 a minute over the last seven years to expand its capacity.

▲

SIXTY years ago this month, Jacob Sechler Coxey led his famous "army" from Massillon, Ohio, to Washington to present a proposal for a large government-financed program of road building to offset the effects of hard times. He was labled a crackpot and a dangerous radical.

Today, his proposal forms a regular item of political thinking.

▲

AVERAGE starting salaries of January engineering graduates at Illinois Institute of Technology reached an all-time high of $373 per month. This is somewhat above the national average due to the number of students having previous working experience in industry.

▲

ACCORDING to the American Iron and Steel Institute, steel production in 1953 averaged 1,398 lb for each person in the country. In 1946, it was 943 lb per person.

There's a reason . . .

Look at the nameplates on the instruments in your plant . . . and in any other plant you may happen to visit. Chances are you'll find a large percentage of them bear the *ElectroniK* name. For the fact of the matter is that literally thousands of different industrial plants have purchased a total of more than eighty thousand of these instruments in the past fourteen years.

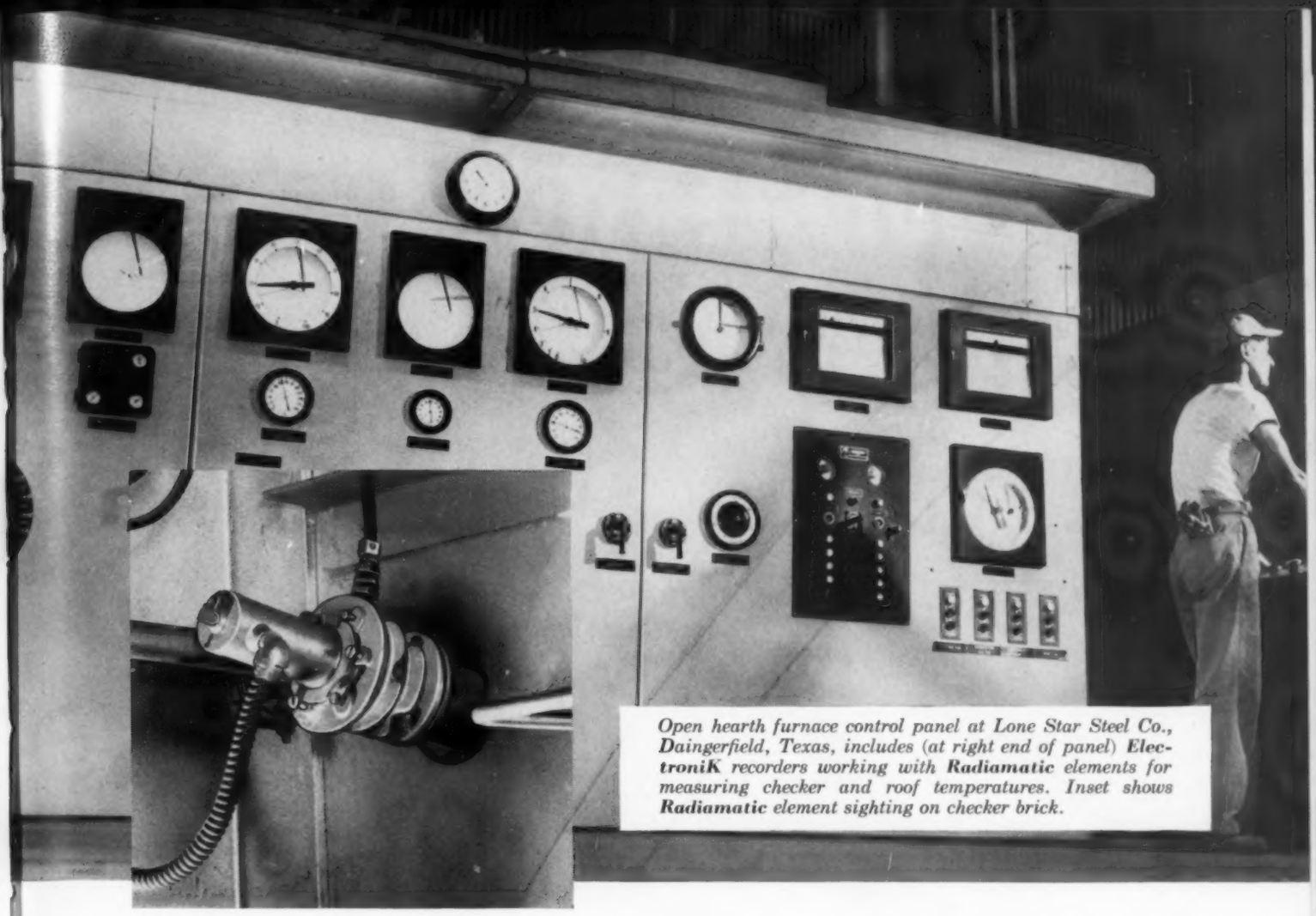
The list of companies who have chosen *ElectroniK* instruments reads like the "Who's Who" of industry. It includes leading manufacturers, large and small alike who have ordered and reordered *ElectroniK* instruments for all types of measuring, recording and controlling assignments.

This widespread acceptance didn't just happen. Some of it is doubtless due to the fact that this was the pioneer electronically operated instrument available to industry on a practical, economical basis. And because it was . . . and is . . . the leader in its field, it has behind it a uniquely broad background of development and application experience. Men in production, engineering, maintenance and research have come to know what this instrument can do, and to rely on it in the most exacting jobs.

Equally important is the excellent record which *ElectroniK* instruments have earned for themselves. They have proved their performance, in sensitivity and precision that set the standard of industry. Their versatility has opened the way to better measurement and control of temperature, flow, pH and dozens of other variables. And their simple, rugged construction has reduced maintenance to a minimum . . . and set records of dependable service under the toughest and dirtiest factory conditions.

For vital temperatures in open-hearths choose the . . .

In this catalog are listed the varied types of ***Radiamatic*** *Pyrometers,* ***ElectroniK*** *instruments and accessories for industrial temperature measurement and control.*



Open hearth furnace control panel at Lone Star Steel Co., Daingerfield, Texas, includes (at right end of panel) ***ElectroniK*** *recorders working with* ***Radiamatic*** *elements for measuring checker and roof temperatures. Inset shows* ***Radiamatic*** *element sighting on checker brick.*

. versatile *Radiamatic* Pyrometers

MANY TEMPERATURES which critically affect the operation of open hearth furnaces are beyond the capabilities of thermocouple measurement. For these applications—call on *Radiamatic* Pyrometers. They're the accurate and economical answer to high temperatures, destructive atmospheres, severe vibration . . . and many other difficult installation conditions.

For checker temperatures, for example, *Radiamatic* Pyrometers give a more accurate guide for reversal by measuring actual temperature of the checker brick. They outlast couples many times over . . . reduce replacement and maintenance cost. For roof temperatures, the *Radiamatic* system provides dependable precision that allows furnaces to be run to their maximum safe limit.

Radiamatic elements are temperature compensated. They are as easy to interchange as thermocouples. An extensive selection of open and closed end sighting tubes and mounting accessories makes them readily applicable to any steel mill installation. Working with these elements is a broad choice of *ElectroniK* indicating, recording and controlling instruments . . . the family of pioneer "Continuous Balance" instruments whose performance sets the standard of the industry.

Your nearby Honeywell sales engineer will be glad to discuss how *Radiamatic* Pyrometers can help in your mill. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Aves., Philadelphia 44, Pa.

● **REFERENCE DATA: Write for your copy of new Catalog 9301, "*Radiamatic* Pyrometers."**

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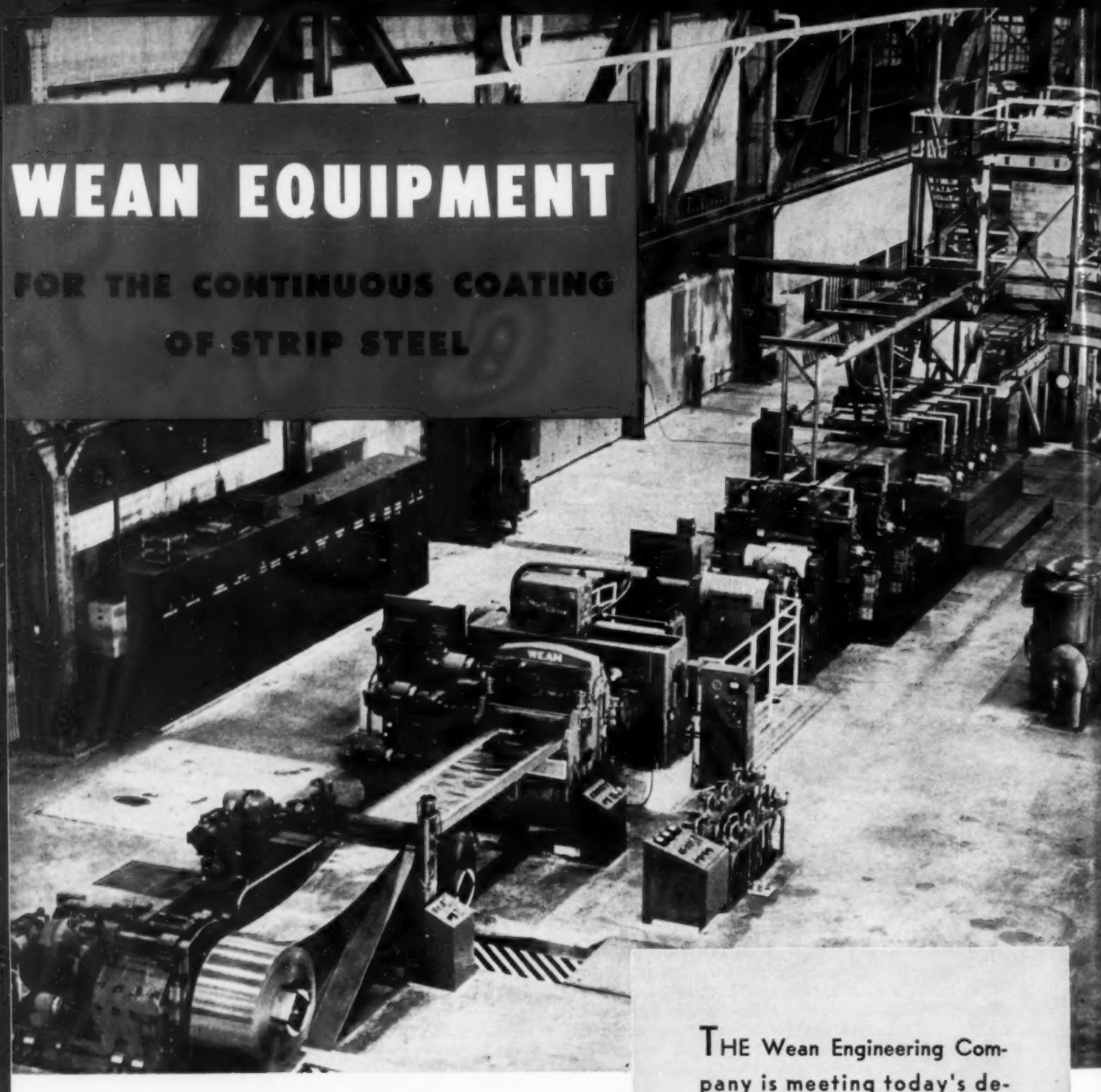
Honeywell
BROWN INSTRUMENTS
First in Controls



WEAN EQUIPMENT

FOR THE CONTINUOUS COATING OF STRIP STEEL

THE Wean Engineering Company is meeting today's demands for equipment to produce tin plate and zinc coated strip steel with light coatings by the electrolytic method; also equipment to produce chemically treated black plate and strip steel. Equipment for coating strip steel with zinc and other materials by the hot dip method is also available.

The WEAN ENGINEERING COMPANY, Inc.

WARREN ---------- OHIO

Associate Company—Wean Equipment Corp.—Cleveland, Ohio

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Empire Building
Pittsburgh, Pa.

Iron and Steel ENGINEER

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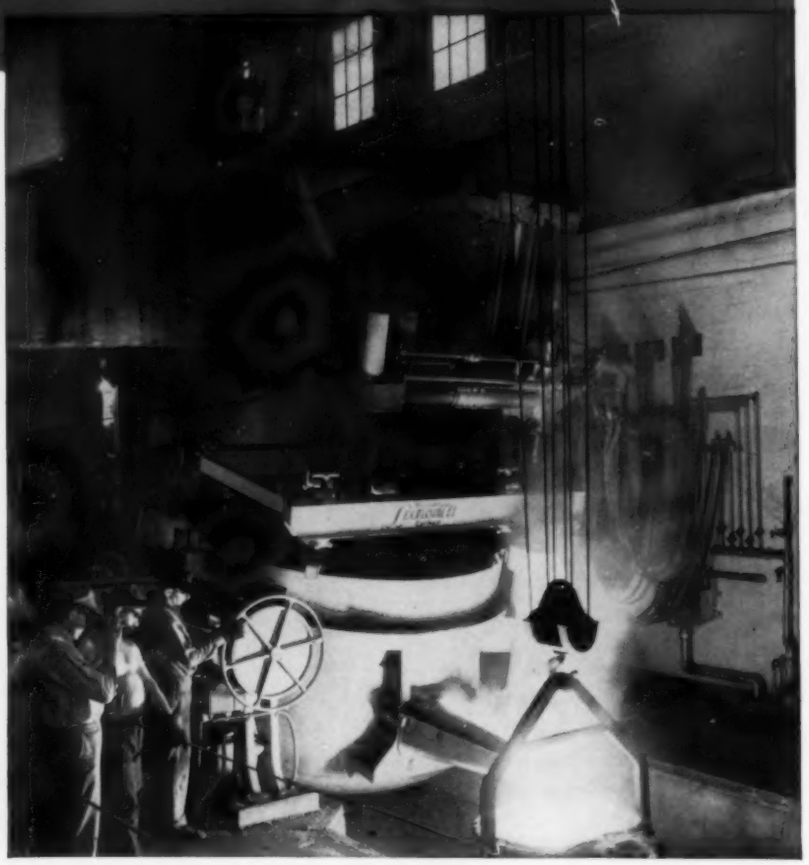

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MOORE RAPID

WHEN YOU MELT... *Lectromelt*

COST COMPARISONS
of the
OPEN HEARTH *and* ELECTRIC FURNACE

By DAVID D. MOORE
Chief, Engineering Economics Division
Battelle Memorial Institute
Columbus, Ohio

. . . . a report on some very elaborate and detailed studies on the future of steelmaking . . . .

▲ PRODUCTION of steel in the electric furnace has been practiced for half a century or more, but until after World War II it was used only for the manufacture of high-alloy steels, for which the electric furnace is peculiarly adapted. Wartime and postwar improvements in furnace design and operations have lowered the cost of electric-furnace steelmaking to the point where its use to produce plain-carbon steels appears to be economically feasible—at least under certain favorable situations.

Any strong upward trend in the use of the electric furnace would create important new markets for electric power and for coal to produce the bulk of this electric energy. In order to evaluate the present and potential competitive aspects of the electric-furnace and open-hearth processes in making low-carbon steels, a group of fourteen electric utilities and Bituminous Coal Research, Incorporated, sponsored a recent comprehensive study on this subject at Battelle Memorial Institute. This paper is essentially a condensation of that study.[1]*

Cost-comparison estimates were developed for representative modern plants of 250,000 tons, 500,000 tons, and 1,000,000 tons of ingots per year employing cold-metal practice, and for the latter two sizes using 50-50 hot-metal/cold-scrap practice. Data on costs—capital

*Numbers refer to Bibliography.

TABLE I

Estimated Capital Costs of Open-Hearth and Electric-Furnace Shops, 1952 Price Levels

	250,000-Ton shop		500,000-Ton shop		1,000,000-Ton shop	
	Open hearth	Electric furnace	Open hearth	Electric furnace	Open hearth	Electric furnace
1. Buildings and foundations	$ 3,500,000	$ 1,500,000	$ 5,000,000	$ 2,500,000	$ 8,000,000	$ 3,500,000
2. Furnaces and auxiliaries	2,250,000①	1,250,000②	3,500,000③	2,000,000④	6 000,000⑤	4,000,000⑥
3. Scrap-handling and charging equipment	1,250,000	750,000	2,000,000	1,250,000	3,000,000	1,750,000
4. Pit side equipment	1,750,000	1,250,000	1,750,000	1,750,000	3,250,000	2,750,000
5. Stripper facilities	1,000,000	1,000,000	1,750,000	1,500,000	2,100,000	1,750,000
6. Molds and mold-conditioning plant	500,000	500,000	750,000	750,000	1,250,000	1,000,000
7. Storage facilities	250,000	150,000	400,000	250,000	550,000	400,000
8. Utilities	1,250,000	350,000	1,750,000	500,000	2,500,000	750,000
Total	$11,750,000	$ 6,750,000	$16,900,000	$10,500,000	$26,650,000	$15,900,000

① Three 150-ton furnaces.
② Three 18-foot furnaces with 20,000-kva transformers.
③ Four 200-ton furnaces.
④ Four 20-foot furnaces with 25,000-kva transformers.
⑤ Eight 200-ton furnaces.
⑥ Eight 20-foot furnaces with 25,000-kva transformers.

TABLE II

Material Balances in Open Hearths and Electric Furnaces Operating on a 100 Per Cent Cold-Metal Charge

	Open hearth①		Electric furnace②	
	Pounds per ton of ingots	Per cent of input and output	Pounds per ton of ingots	Per cent of input and output
	Input		Input	
Pig iron	556	8.5	173	7.5
Steel scrap③	1668	25.0	1985	85.0
Ore (58 per cent Fe)	24	0.4	50	2.1
Electrodes	....	....	12	0.5
Limestone	20	0.4	30	1.3
Burned lime	60	1.1	75	3.2
Fluorspar	10	0.2	....	....
Fuel oil	250	3.7	....	....
Steam	100	1.5	....	....
Air	3875	59.0	....	....
Finishing additions	12	0.2	12	0.4
Total	6575	100.0	2337	100.0
	Output		Output	
Ingots	2000	30.0	2000	86.5
Scrap and ingot butts	60	1.4	60	4.8
Slag	200	3.1	157	6.2
Flue or waste gases	4295	65.0	120	2.5
Flue dust	20	0.5	....	....
Total	6575	100.0	2337	100.0

① Fuel consumption, 4,600,000 Btu per ton of ingots. Ingot yield, 89 per cent.

② Ingot yield assumed to be 91 per cent. This yield is an average figure obtained from data collected in this survey and is lower than yields claimed in various technical literature.

③ This weight will be increased in each case by dirt charged with scrap and furnace refractories fluxed.

and operating—were obtained from a considerable number of steel companies, engineering construction firms, and equipment manufacturers. These were carefully appraised, compared, adjusted, and finally tempered with some theory and extrapolations dealing with hot-metal practice in the electric furnace. The resultant cost figures are believed to be reasonably representative of 1952 costs for modern plants of the sizes given. On the other hand, it should be emphasized that actual costs of any plant could vary from those shown,

TABLE III

Material Balances in Open Hearths and Electric Furnaces Operating on a 50-50 Hot-Metal and Cold-Scrap Charge

	Open hearth①		Electric furnace②	
	Pounds per ton of ingots	Per cent of input and output	Pounds per ton of ingots	Per cent of input and output
	Input		Input	
Liquid pig iron	1126	18.7	1103	44.8
Cold steel scrap	1126	18.7	1103	44.8
Ore (58 per cent Fe)	150	2.5	120	4.9
Electrodes	....	....	10	0.4
Limestone	100	1.9	35	1.4
Burned lime	13	0.2	80	3.2
Fluorspar	10	0.2	....	....
Fuel oil	180	3.0	....	....
Steam	75	1.4	....	....
Air	3208	53.2	....	....
Finishing additions	12	0.2	12	0.5
Total	6000	100.0	2463	100.0
	Output		Output	
Ingots	2000	33.3	2000	81.2
Scrap and ingot butts	60	1.4	60	2.4
Slag and other losses	300	5.0	192	7.8
Flue or waste gases	3620	60.0	211	8.6
Flue dust	20	0.3	....	....
Total	6000	100.0	2463	100.0

① Fuel consumption 3,300,000 Btu per ton of ingots. Ingot yield, 87 per cent. No flush practice.

② Ingot yield assumed to be 88 per cent. No flush practice.

TABLE IV

Estimated Heat Balances for Open Hearths Operating on Cold-Metal and 50-50 Hot-Metal and Cold-Scrap Charges

	Cold-metal charge		Hot-metal charge	
	Btu per ton of ingots	Per cent	Btu per ton of ingots	Per cent
	Input		Input	
1. Heat of combustion of fuel	4,600,000	94.0	3,300,000	69.2
2. Sensible heat in fuel	115,000	2.4	95,000	2.0
3. Heat content in liquid pig iron	.....	....	550,000	11.5
4. Exothermic reactions	175,000	3.6	831,000	17.3
Total	4,890,000	100.0	4,776,000	100.0
	Output		Output	
5. Heat content of liquid steel	1,260,000	25.8	1,260,000	26.4
6. Heat content of slag	186,000	3.8	270,000	5.6
7. Calcination of limestone	.....	....	118,000	2.5
8. Reduction of iron ore	43,000	0.9	100,000	2.1
9. Evaporation and heating of water in charge	420,000	8.6	315,000	6.6
10. Loss in stack gases	1,340,000	27.4	960,000	20.0
11. Heat dissipated in cooling water	260,000	5.3	232,000	4.8
12. Loss through walls, radiation, etc.	1,381,000	28.2	1,521,000	32.0
Total	4,890,000	100.0	4,776,000	100.0

depending on the plants' location, modifications in design, and any changes in other variable factors such as fuel or electric power costs.

CAPITAL COSTS

Estimated capital costs for the open-hearth and electric-furnace plants are shown in Table I. The table shows that capital costs for electric-furnace plants were $6,750,000 for the 250,000-ton plant, $10,500,000 for the 500,000-ton plant, and $15,900,000 for the 1,000,000-ton plant. These costs run about 60 per cent of the cost of comparable-sized open hearths. Actually, the estimated annual capacities of the electric furnaces in cold-melt practices are somewhat greater than of the open hearths, so capital cost differentials might be somewhat greater than those shown. Although there is no established background for operating the electric furnace on a hot-metal/cold-scrap practice, ingot output for hot-metal operations should be at least as great as for a cold-melt shop.

It is recognized that a modern open-hearth plant designed to produce 1,000,000 tons of ingots annually would use 250 or 275-ton furnaces. Following the same reasoning, a comparable-sized, electric-furnace plant would use 24-foot furnaces. However, it is believed that the additional costs for these heavier furnaces would tend to offset capital savings due to a decrease in number of furnaces. Also, the smaller-sized furnaces provide a more direct comparison of different size plants.

MATERIAL AND HEAT BALANCES IN THE OPEN-HEARTH AND ELECTRIC-FURNACE PROCESSES

Any valid comparison of the relative economics of the two processes must consider their material and heat balances for similar operations. Unfortunately, no precise data for complete material and heat balances of

TABLE V

Estimated Heat Balances of Electric-Arc Furnaces Operating on Cold-Metal and 50-50 Hot-Metal and Cold-Scrap Charges

	Cold-metal charge		Hot-metal charge	
	Kwhr per ton of ingots	Per cent	Kwhr per ton of ingots	Per cent
	Input		Input	
1. Power into transformers	525	100.0	470	76.0
2. Heat content of liquid iron	....	....	151	24.0
Total	525	100.0	621	100.0
	Output		Output	
3. Heat content of liquid steel	370	70.5	370	59.6
4. Heat content of slag	22	4.2	29	4.7
5. Refining reactions①	6	1.2	66	10.6
6. Heat content of waste gases	12	2.3	45	7.3
7. Heat extracted by cooling water	20	3.8	20	3.2
8. Electrical losses	40	7.6	36	5.8
9. Losses through walls, radiation, etc.	55	10.4	55	8.8
Total	525	100.0	621	100.0

① Oxidation of silicon, manganese, and phosphorus by iron ore produces heat, but oxidation of carbon by the ore is an endothermic reaction. The net effect of all refining reactions is a loss of heat.

these processes are available in the published literature. Calculations were therefore necessary to arrive at comparable material and heat balances. Material balances for the open hearth and electric furnace using a cold-metal charge are shown in Table II, while Table III shows the same comparison using 50 per cent hot metal. Table IV shows the heat balances for the open-hearth operations—both cold—and hot-metal charges. Heat balances for electric-furnace operations are shown in Table V. Both sets of calculations were made for a 200-ton open-hearth furnace and for a 20-foot electric-arc furnace using either a cold-melt or a 50-50 hot metal/cold-scrap charge. The calculations are patterned after those given by T. J. Ess[2, 3] and employ the same values of thermochemistry on which Ess's calculations were based, as well as fuel and combustion data given in Basic Open-Hearth Steelmaking [4]. Many of these items, however, were modified to conform with data obtained in the present study[1]. Calculations for the electric furnace using 50 per cent hot metal are of course based on estimates without much supporting data.

It is of interest to note that the metallic charges for the open hearth are much smaller than the air required for combustion. This comparison is even more striking on the output side where the stack gases constitute about twice the weight of the finished ingots. Conversely, the metallic charge and yields of the electric furnace are both above 90 per cent of the total input and output using cold-melt operations. For a 50-50 hot-metal charge, the metallics amount to about 92 per cent of the input and 83 per cent of the output.

The differences in thermal balances between the two types of processes are just as striking. In the open hearth, about 26 per cent of the heat input is contained in the molten steel, from 20 to 27 per cent is lost in stack gases, and 28 to 32 per cent is lost through furnace walls, radiation, etc. On the other hand, the heat balance in the electric furnace using a cold charge shows that more than 70 per cent passed to the steel.

TABLE VI

Estimated 1952 "Cost Above" per Ton of Ingots in Open-Hearth and Electric-Furnace Shops of 250,000, 500,000 and 1,000,000 Tons Annual Capacity

	Cold-metal charge						50 Per cent hot-metal charge			
	250,000-Ton capacity		500,000-Ton capacity		1,000,000-Ton capacity		500,000-Ton capacity		1,000,000-Ton capacity	
	Three 150-ton open-hearth furnaces	Three 18-foot electric furnaces	Four 200-ton open-hearth furnaces	Four 20-foot electric furnaces	Eight 200-ton open-hearth furnaces	Eight 20-foot electric furnaces	Four 200-ton open-hearth furnaces	Four 20-foot electric furnaces	Eight 200-ton open-hearth furnaces	Eight 20-foot electric furnaces
1. Fuel oil ($0.60 per MM Btu)	$ 2.76		$ 2.76		$ 2.76		$ 1.98		$ 1.98	
2. Power (9 mills)		$ 4.70		$ 4.70		$ 4.70		$ 4.25		$ 4.25
3. Electrodes ($0.18)		2.15		2.15		2.15		1.80		1.80
4. Fluxes	0.69①	0.62②	0.69①	0.62②	0.69①	0.62②	0.50③	0.67④	0.50③	0.67④
5. Furnace refractories	0.80	0.60	0.70	0.50	0.70	0.50	0.70	0.45	0.70	0.45
6. Ladle refractories (ladle brick sleeves, nozzles, etc.)	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
7. Furnace repairs (masonry, labor, materials)	1.80	1.20	1.60	1.30	1.60	1.30	1.50	1.20	1.50	1.20
8. Molds and stools (replacement and conditioning)	0.65	0.85	0.65	0.85	0.65	0.85	0.65	0.85	0.65	0.85
9. Production labor ($2 per man-hour)	2.20	1.70	2.00	1.35	2.00	1.35	1.60	1.25	1.60	1.25
10. Maintenance labor and materials	0.95	0.95	0.85	0.80	0.70	0.65	0.70	0.70	0.55	0.55
11. Indirect labor (supervision, metallurgical, clerical, etc.)	0.30	0.35	0.25	0.25	0.20	0.20	0.20	0.25	0.20	0.20
12. Oxygen and compressed air	.....	0.28	.....	0.28	.....	0.28	0.20	0.28	0.20	0.28
13. Supplies, tools, lubricants, etc.	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
14. Water and other utilities	0.35	0.35	0.35	0.35	0.35	0.35	0.30	0.35	0.30	0.35
15. Yard switching	0.25	0.25	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
16. Slag disposal	0.40	0.20	0.35	0.20	0.35	0.20	0.30	0.20	0.30	0.20
17. Employee benefits	0.35	0.30	0.35	0.25	0.35	0.25	0.30	0.23	0.30	0.23
18. General expense (overhead)	0.60	0.50	0.50	0.40	0.45	0.40	0.40	0.40	0.40	0.40
Subtotal	$12.45	$15.35	$11.60	$14.55	$11.35	$14.35	$ 9.88	$13.43	$ 9.73	$13.23
19. Fixed charges (interest, taxes, amortization, etc., computed on the basis of 12 per cent of total capitalization)	5.64	3.24	4.92	2.52	3.88	1.91	4.07	2.52	3.20	1.91
TOTAL	$18.09	$18.59	$16.52	$17.07	$15.23	$16.26	$13.95	$15.95	$12.93	$15.14

① Assumed consumption: 20 lb limestone, 60 lb burnt lime, 10 lb fluorspar

② Assumed consumption: 30 lb limestone, 75 lb burnt lime

③ Assumed consumption: 100 lb limestone, 13 lb burnt lime, 10 lb fluorspar

④ Assumed consumption: 35 lb limestone, 80 lb burnt lime

For a 50 per cent hot-metal charge this drops to about 60 per cent. The loss in efficiency is largely attributable to an estimated loss of about 60 kwhr in the oxidation of carbon by iron ore, a loss only slightly compensated by the exothermic reactions of silicon, manganese, and phosphorous oxidation.

The use of oxygen for carbon elimination when either type of furnace is operated on a high liquid-iron charge may offer certain distinct economic advantages in comparison with ore practice. At an assumed power rate of 9 mills, the cost of 2.8 kwhr of electric energy necessary to carry on the endothermic reaction of carbon elimination by means of ore would be equivalent to about 2.5 cents per pound of oxygen contained in the ore. This cost would be partially offset by the release of metallic iron from the ore, but under present conditions use of oxygen might become economically justified when its cost is less than $34 per ton or $1.35 per Mcf.

PRODUCTION COSTS

In conformance with steel-company practice, ingot production costs are split into: (1) "cost above" which includes the cost of labor, fuel, fluxes, fixed charges, supplies, etc., and (2) cost of metallics in the furnace charge.

"Cost Above" in steelmaking processing, items making up "cost above" fall into one of two major categories:

1. Items directly related to tonnage of production, such as fuels, molds and stools, fluxes, ladle refractories, etc.
2. Items that are more or less constant regardless of hourly output, such as production labor, furnace refractories and repairs, maintenance, yard switching, indirect labor, fixed charges, etc.

Cost of items comprising Group 2 may vary from plant to plant but in open-hearth operations are believed to approximate about one dollar per ton of ingot per gross furnace hour. Because of the shorter time per heat, comparable electric-furnace costs per ton of ingot may run somewhat lower as shown in Table VI. "Cost above" for the open-hearth shops using a cold-metal charge runs from $18.09 per ton of ingot for the 250,000-ton plant to $16.52 for the 500,000 ton plant, and $15.23 for the 1,000,000-ton plant. In comparison, the "cost above" for the electric furnace runs from $18.59 for the 250,000-ton plant to $17.07 for the 500,000-ton plant, and $16.26 for the 1,000,000-ton plant. All of these costs include fixed charges amounting to 12 per cent of total capital costs. The reduction in "cost above" with increasing plant size stems primarily from a decrease in the fixed charges per unit output. It is the informed opinion of many operating men that fixed charges per ton of output tend to become stabilized at a plant capacity of about 1,000,000 tons of ingots annually.

Comparative "cost-above" for the 500,000-ton and 1,000,000-ton plants using 50 per cent hot metal are also shown in Table VI. The "cost above" for the 500,000-ton plants drops from $13.95 for the open hearth and $15.95 for the electric furnace down to $12.93 and $15.14, respectively, for the 1,000,000-ton shops.

It is of interest to note the progressive decrease in "cost above" with increasing plant capacity. While both types of plants enjoy this trend, the open hearth appears to gain more from an increase in plant capacity. In cold-melt operations, the open-hearth "cost above" dropped $2.85 per ton as plant size increased from 250,000 to 1,000,000 tons of ingots, while electric-furnace "cost above" dropped only $2.35 per ton for a corresponding increase. Using a 50 per cent hot-metal charge, "cost above" for the open hearth dropped $1.02 per ton as plant size increased from 500,000 to 1,000,000 tons of annual ingot capacity. The corresponding decrease was only $0.81 for electric-furnace shops.

In determining the "cost above" for the electric furnace using 50-50 hot-metal, cold-scrap charge, a power consumption of 470 kwhr per ton of ingots was assumed (compared with 525 kwhr for cold-metal practice). Electrode consumption was assumed to be 10 pounds per ton of ingot for hot-metal practice, compared with an average of 12 pounds for cold-metal practice.

COST OF METALLICS

The cost of metallics composing the furnace charge is a variable, which may favor any one of the processes depending on the relative market price and availability of scrap and pig iron, and on price differentials between grades of scrap at any given time. Generally, scrap will be lower than pig iron at nonintegrated plants, and thus electric furnaces usually should have a lower metallics cost.

Any losses in metallics have a significant effect on production costs. Based on the findings of this survey, the normal ingot-yield expectancy in the open hearth is about 89 per cent for a cold-metal charge and 87 per cent for a 50 per cent hot-metal charge. In electric-furnace operations, comparable ingot yields are about 91 and 88 per cent, respectively.

Because of the smaller-size heats in electric furnaces, ingot butts will be a larger percentage of the heat. Counterbalancing this to some degree should be the smaller ladle skulls. For the purpose of this study it is assumed that recoverable losses amount to 60 pounds per ton of ingots for either process.

It is generally recognized that unrecoverable losses are greater in the open hearth. In addition to losses from pig iron are the metallics lost in the slag, in slag pockets, in checker chambers, in waste gases, through flushing and unrecoverable spillage, and by other means[5].

As a broad statement, the slag volume in an electric furnace using a cold charge is about one-half that of an open hearth operating on a cold charge; it is only one-third that of an open hearth operating on a 50 per cent hot-metal charge. Electric furnaces using hot-metal practice may be expected to carry more slag but still appreciably less than in the open hearth. Waste gases in the open hearth are another significant source of metallic losses, possibly as much as 3 to 5 pounds per ton of ingot. On the other hand, waste gas volume and metallic losses from this source are negligible in the electric furnace—particularly in cold-melt operations.

Estimated cost of metallics per ton of ingots are shown for both processes in Table VII. In cold-metal

TABLE VII

Estimated Cost of Metallics per Net Ton of Ingots in Open-Hearth and Electric-Furnace Shops

	Cold-metal charge				50 Per cent hot-metal charge			
	Open-hearth		Electric furnace		Open-hearth		Electric furnace	
	Pounds per ton of ingots	Cost per net ton	Pounds per ton of ingots	Cost per net ton	Pounds per ton of ingots	Cost per net ton	Pounds per ton of ingots	Cost per net ton
Steel scrap at $43/gross ton	1668	$32.00	1985	$38.10	1126	$21.60	1103	$21.18
Pig iron at $58/gross ton	556	14.45	173	4.50	1126	18.58	1103	18.20
Iron ore (lump) at $14/gross ton	24	0.15	50	0.30	150	0.85	120	0.75
80 Per cent ferromanganese at $225/gross ton	12	1.20	12	1.20	12	1.20	12	1.20
Total gross cost of metallics		$47.80		$44.10		$42.23		$41.33
Less credit for 60 pounds of recoverable steel scrap		1.15		1.15		1.15		1.15
Net cost of metallics per net ton of ingots		$46.65		$42.95		$41.08		$40.18

practice, the estimated net cost of the metallics amount to $46.65 per ton for the open hearth compared with $42.95 for the electric furnace, a difference of $3.70 favoring the electric furnace. In hot-metal practice, the net cost drops to $41.08 for the open hearth and $40.18 for the electric furnace, a difference of only $0.90 in favor of the electric furnace.

PERFORMANCE AND STEEL-QUALITY FACTORS

Factors other than a dollar and cents comparison should be used in evaluating the relative worth of the two processes. These considerations include such items as performance and steel quality.

Flexibility, Availability and Ingot Yield—The electric furnace has a much greater flexibility. If necessary, an electric-furnace plant could be operated on one shift daily and closed down completely on week ends. In contrast, the open hearth must be operated on a continuous basis to prevent a greatly shortened furnace life and undue delays in bringing the furnace to steelmaking temperatures.

Operating at 100 per cent capacity, the greater flexibility of the electric-arc furnace may not be an important economic factor, but, as operating rates decrease, this flexibility becomes increasingly important. For example full-scale operations can be maintained on individual electric furnaces, thereby keeping "cost above" and other production costs constant. On the other hand, costs would increase in the open-hearth shop because of cut-back operations with furnaces operating at partial capacity. Also, the lower capital cost for electric-furnace plants of similar capacity would mean less of an increase in fixed costs per ton of steel as productivity decreased. Offsetting these advantages to some degree, intermittent or reduced electric-furnace operations might result in increased electric-power rates.

Furnace availability is another factor favoring the electric-furnace shop. The study indicates that the availability of the modern arc furnace is about 96 per cent compared with 92 per cent for the open hearth. Thus, greater sustained outputs can be maintained with the electric furnace.

Ingot yields for the electric furnace are estimated to be some 2 to 3 per cent greater in cold-melt practice. Actual yields for both processes would be lower using hot-metal practice, but from information gathered in this study it would appear that the yield from the electric furnace would still be from 1 to 2 per cent more than from comparable open-hearth operations.

Steel-Quality Factors—The importance of steel quality varies with grade of steel desired and may be either minor or of overriding importance. The most significant quality factors are concerned with residual elements and temperature control in the processing operations.

Residual Elements—In making plain-carbon steel, carbon, manganese, silicon, phosphorus, and sulphur are so-called common elements, the contents of which are adjusted to meet the desired chemical and mechanical specifications. Besides these major elements, certain contaminants are generally present in steel. To this group belong nickel, copper, molybdenum, vanadium, lead, tin, antimony, and arsenic. With the exception of tin, and the particularly objectionable lead, antimony, and arsenic, these metals are useful elements in various alloy steels but may impart undesirable properties to plain-carbon steels.

Steel scrap is a major source of the residual metals that are not eliminated. In cold-melt operations, electric-furnace steelmaking uses a higher percentage of scrap in the furnace charge, so the residual or "tramp" metals will tend to be greater in the finished products. For hot-metal operations, there would, of course, be little difference in residual metal contents.

Sullivan, et al[6], presented a paper at the open-hearth conference in 1945 indicating that the content of tramp elements was levelling off at levels not presenting serious difficulties. However, information garnered in this study indicates that the content of residual elements in steel may have resumed an upward trend.

Sulphur—Sulphur is generally considered to be an undesirable element in most steelmaking applications except for improving machining qualities. Standard specifications place maximum sulphur limit at 0.040 per cent, but for many steels, a sulphur content below 0.025 per cent would be desirable. For some special applications such as welding rods, a sulphur content below 0.020 is often necessary. This may create a serious problem in open-hearth operations, depending on the sulphur content of the pig iron and residual fuel. In open-

hearth operations, an equilibrium is established between sulphur content of furnace gases and sulphur in the molten steel. Temperatures of the bath and basicity of the slag must be increased to reduce the sulphur content in the steel. Such a practice slows down furnace operation and increases the steelmaking costs.

Currently, the average sulphur content of residual fuel oil used by eastern steel plants averages more than 1.0 per cent compared with around 0.5 per cent ten years ago. There are some indications[7] that this trend has been arrested, or even reversed, through recent major discoveries of low-sulphur crude oils, but any further upward trend in sulphur content of residual fuel could prove costly in open-hearth operations.

In contrast, electric-furnace operations permit rapid adjustments in composition of slag and temperature to expedite sulphur removal. Moreover, a major source of sulphur contamination—the fuel—is avoided. This facility in sulphur control might become a compelling factor in a long-range future balance between the two processes.

Temperature Control—The rate at which fuel can be burned in any presently designed open hearth is limited by the means of heat input. Attempts to increase this rate of heat input (by higher preheat of combustion air, increase in fuel consumption, or the use of oxygen-enriched air in burning this fuel) may burn out the roof, or parts, and will certainly shorten the furnace life. Conversely, in the arc furnace, the rate of heat input is limited only by the rate of heat transfer in the bath, and temperatures may be raised in a much shorter time period. As a broad statement, temperature control is much simpler in electric-furnace steelmaking.

IMPORTANT FACTORS IN FUTURE COSTS

The present and future trends in costs and availability of the various raw materials and types of energy are major factors in determining comparative costs for electric-furnace and open-hearth steelmaking. As requirements for certain of these materials and types of energy vary widely between the two processes, factors tending to increase or decrease their individual costs may have a decided influence on their relative economics at any given place or time.

Fuels—Coal, petroleum, and natural gas are used directly and indirectly in making all types of steel. Factors tending to upset present cost relationships among these fuels could have a decided influence on comparative costs of open-hearth and electric-furnace steelmaking. Therefore, a brief analysis of potential future trends in relative prices or costs of coal, petroleum, and natural gas should be included.

Future Trends in Cost and Availability—Predictions of conditions as they may exist 15 years or more hence can be little more than pure conjecture. Variables such as technological changes, governmental controls, international conditions, and basic supplies limit the accuracy obtainable.

However, to assist long-range planning and evaluations, an attempt has been made to show the general trends that may develop. It is felt that showing the relative price trends in terms of an actual Btu valuation is helpful in visualizing these predicted trends. It should be understood that wide variations from these trend lines will occur from year to year and even over a period of several years. However, it is believed that the long-range trend will be in the general range shown in Figure 1.

The figure shows natural gas prices at the well increasing during the next several years until they approach those of coal fob the mine. By 1975, going field prices for gas in the Southwest may be as much as 25 to 30 cents per Mcf compared with 10 to 15 cents at present. However, because of the long-term contracts for natural gas reserves, the average field price should be somewhat lower.

On the other hand, natural gas in interstate commerce is a controlled utility and as such is less susceptible to rapid price fluctuations reflecting inflationary or deflationary conditions. There can be no doubt that the inflationary trends since 1940 have been a major item in the improved price position of natural gas compared with coal and oil. Under a continued inflationary economy, natural gas may hold or improve its present price relationships in spite of predicted, increased delivered prices.

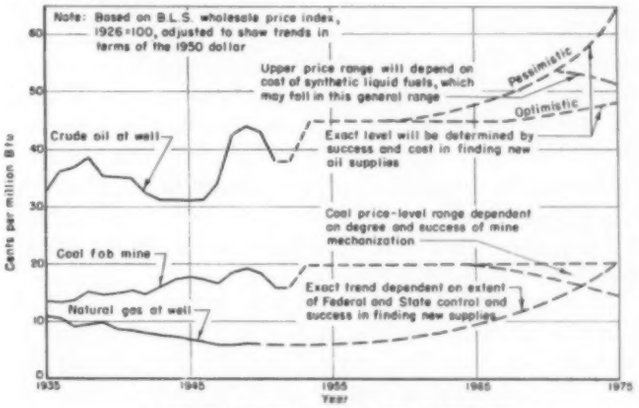
Note: Based on B.L.S. wholesale price index, 1926=100, adjusted to show trends in terms of the 1950 dollar
Upper price range will depend on cost of synthetic liquid fuels, which may fall in this general range
Pessimistic
Optimistic
Crude oil at well
Exact level will be determined by success and cost in finding new oil supplies
Coal price-level range dependent on degree and success of mine mechanization
Coal fob mine
Exact trend dependent on extent of Federal and State control and success in finding new supplies
Natural gas at well
Cents per million Btu
60
50
40
30
20
10
0
1935
1945
1955
1965
1975
Year
Sources U.S. Bureau of Mines and Bureau of Labor Statistics

Figure 1 — Past, present, and potential trends in average United States price levels of primary mineral fuels, 1935-1975.

Coal prices, through expansion of radical mine mechanization, should not rise materially over levels existing in 1950. By 1975, they might drop back to 25 per cent below the 1950 level.

The future potential price trends for crude oil are more uncertain. Much of the production even five years hence will come from new sources and developments during that period. Over a long period, there is also the possible limitation to price rise set by the future cost of making synthetic liquid fuels by improved means. If recoverable reserves of crude oil can be expanded through improved drilling and recovery methods and ultimate resources are sufficiently great, crude oil prices by 1975 may be less than 10 per cent above 1950 levels. Under more pessimistic conditions, prices would be set by alternative costs of synthetic liquid fuel. Depending on the developments in synthetic fuel processes, this might mean an increase in prices of from 25 to 50 per cent by 1970 to 1975, compared with 1950 prices.

Comparative Fuel Economics of Electric-Furnace and Open-Hearth Operations—Based on future price trends as shown in Figure 1, little variation in present price competition between coal and oil is foreseen dur-

ing the next ten years. Thus, excepting areas where natural gas is used, changes in fuel economics for electric-furnace and open-hearth operations will be minor. In plants using natural gas, increases of from 10 to 20 cents per ton of ingot may occur.

By 1975, price levels of residual fuel in the East North Central States and Alabama may be up by 25 per cent, while delivered natural gas prices will be at least 10 to 20 cents per Mcf above present rates. On the other hand, coal prices may be at or below present price levels.

This would mean a possible increase in the "costs above" for an open-hearth shop, amounting to about 30 to 40 cents per ton of liquid steel. Conversely, a reduction in coal costs of 10 per cent could reduce the electric power costs for electric-furnace operations by about 15 cents per ton of liquid steel.

Thus, by 1975, shifts in fuel costs might improve the economics of electric-furnace versus open-hearth steel plants by as much as 50 cents per ton of liquid steel produced.

The situation on the East Coast is somewhat different. Coal is presently unable to undersell residual fuel in many areas. With increased prices for residual fuel, there would be a natural tendency to increase the price of the coal to some degree. Basic costs of foreign crudes will not increase as rapidly as those in the United States. Assuming continuing access to Middle East and South American crudes, residual fuel prices on the East Coast may not increase appreciably during the next 15 to 20 years, unless intensified and broadened foreign nationalistic developments result in higher oil prices, which may well happen.

It is concluded that if imports are not restricted, competition between coal and oil will remain similar to present. On the other hand, a prohibitive tariff on imports would soon throw residual fuel into a noncompetitive price bracket such as now exists in the East North Central states.

Electrodes—Graphite electrodes are a major cost in the making of electric-furnace steels. Depending on the type of operation, from 10 to 12 pounds of electrodes may be consumed per ton of steel produced. At a 1951 average delivered price of 18 cents per pound, the average cost for electrodes per ton of steel is close to $2.

Petroleum coke is the basic raw material from which graphite electrodes are made, but, under present price levels, the cost of the "green" coke is less than five per cent of the average delivered price of the electrode. Electric power is another major item in the cost of graphite electrodes, about three kwhr being consumed per pound of finished electrode. Even so, an increase of one mill per kwhr in power rate would amount to only about three cents difference in electrode cost per ton of steel produced.

It would appear that manufacturing and freight costs are more important factors in determining the selling price of graphite electrodes. Both of these costs may be expected to follow general price trends, so even relatively large shifts in costs of electric power or petroleum coke might have only minor effect on the delivered cost of graphite electrodes.

The use of continuous, self-baking electrodes has been practiced to some extent in Russia[8], Norway, and Sweden, and there is some belief that future research may permit their economic use in the United States. However, when weight, size, and consumption rates of these electrodes are taken into account, their future utilization does not appear to be too promising.

Steel Scrap and Pig Iron—The present blast furnace capacity in the United States is about 72,000,000 tons of pig iron annually. If this supply should exceed the demand, some of these furnaces will shut down, but the price of pig iron will not be materially lowered. In contrast, the price of steel scrap is governed exclusively by supply and demand, and its supply during the next few decades should be ample, except for temporary dislocations.

The balance between the market price of steel scrap and pig iron will influence the relative economics of small open-hearth and electric furnace plants which own no blast furnaces. In larger integrated steel plants, the cost of hot metal will be considerably lower than the market price of pig iron. Steelmaking units in such plants will employ, therefore, a larger percentage of pig iron (in the form of hot metal) than those of the smaller plants. Under such conditions, the market price of steel scrap and pig iron will be less of a factor in influencing the choice between open-hearth and electric furnace steelmaking. Excepting abnormal conditions, the use of hot metal in nonintegrated steel plants does not appear to be economically justifiable, because the only way this could be accomplished at the present time is by remelting pig iron in a cupola. The cost of remelting would approximate $4 to $5 a ton at the current labor and coke costs. The advantages gained from using hot metal in either the electric furnace or open hearth would not compensate for this added cost. Considerable research is currently devoted to smelting iron ores in short-shaft furnaces with the use of oxygen and reduced coke requirements. If this research should prove successful, the use of hot metal in small steelmaking plants may become practical. It is evident, however, that such a development would not influence materially the relative economics of open-hearth and electric-furnace steelmaking.

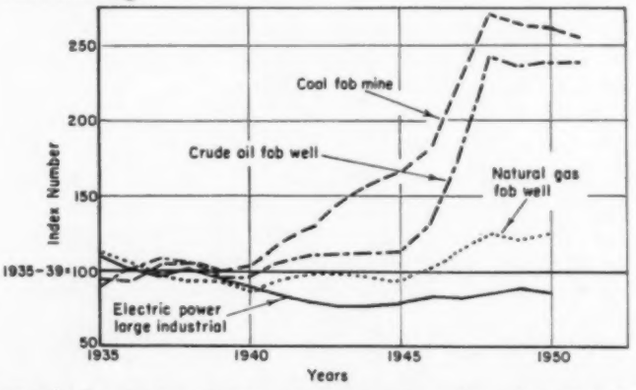

Figure 2 — Indexes of trends in average sales value of coal, crude oil, natural gas, and electric power, 1935 to 1950, based on index 1935-1939=100.

Electric Power—The growth of electric power has been at a faster rate even than that of natural gas. Since 1920, its use has about doubled every ten years. In 1950, the total generation of electric power was 389,000,000,000 kwhr. During 1951, generation jumped 11.2

per cent to 432,000,000,000 kwhr, of which 24.1 per cent was from water power.

A recent projection of electric power demand shows a requirement for the generation of 1,400,000,000,000 kwhr in 1975, more than three times the generation in 1951[9]. These projected, continuing, vast annual increases in electric power demand result in considerable part from the belief that future costs for electric power relative to those of other forms of energy will continue to decline. It would be well to examine some of the more important reasons for this belief.

Figure 2 compares the trend in large industrial power rates with average sales values of coal, crude oil, and natural gas at the source. While both coal and crude oil prices are about 2.5 times their average sales values for 1935-39, natural gas prices have risen only 25 per cent, and average electric power rates for large industrial users have declined by 15 per cent.

Figure 3 shows the above comparison in terms of an average 1935-39 dollar based on the Bureau of Labor Statistics' Wholesale Price Index. On the above basis, coal prices in 1950, fob the mine, were 30 per cent above the 1935-39 average but declined to 13 per cent above the average during 1951. Crude oil prices at the well were 15 per cent above the average in 1950 but declined to only 3 per cent above the average in 1951.

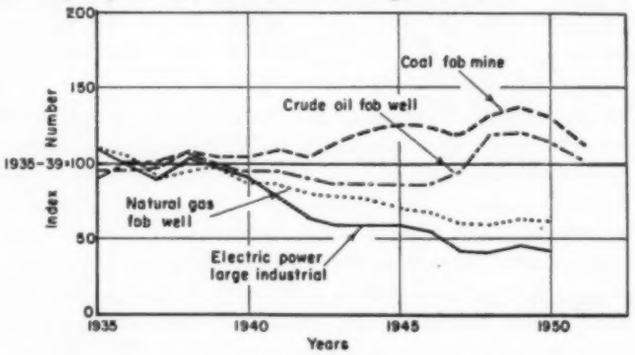

Figure 3 — Indexes of trends in average sales value of coal, crude oil, natural gas, and electric power, 1935-1950, using an average 1935-1939 dollar based on Bureau of Labor Statistics price index.

In contrast to coal and crude oil, on a 1935-39 dollar basis, both natural gas and electric power have shown significant declines in selling prices. Natural gas in 1950 was selling for only 62 per cent as much as its 1935-39 average, while electric power rates were only 41 per cent of their 1935-39 average.

Plant construction costs and production expenses represent the major cost items in generation of electric power. During the past 25 years, significant engineering developments have cut production expenses markedly. The reduction in fuel requirements has been particularly striking. Figure 4 shows that the average pounds of coal per kwhr of power generated in the United States have declined from two pounds per kwhr in 1925 to 1.14 pounds in 1951, based on an average heat value of 13,100 Btu per pound.

By 1975, average fuel consumption may be in the range of 0.7 to 0.8 pound of coal, or possibly even lower. In view of the expected tripling in electric power demand by 1975, a minimum of two-thirds of the power generation must come from new facilities, and thermal generation is expected to expand its present share of the total output. New, large-scale, thermal plants are already achieving efficiencies of 0.7 to 0.8 pound of coal per kwhr. In addition, the vast bulk of the pre-World War II equipment will be junked by 1975. It can therefore be expected that a minimum of from 80 to 85 per cent of all thermal generating equipment in use in 1975 will be modern by present-day standards. If higher load factors and continuing engineering improvements, including radical new designs, can be realized, average equivalent coal consumption conceivably may drop to as low as 0.6 pound per kwhr.

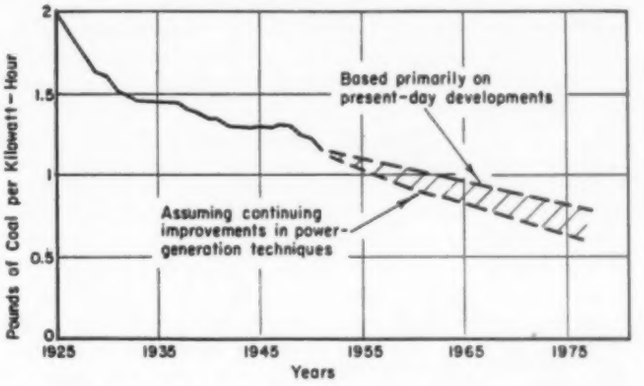

Figure 4 — Trend in fuel economy at electric-utility power plants, 1925-1951, showing estimated trends to 1975.

If the future costs of fuels remain relatively unchanged on a constant dollar basis, significant savings in fuel costs may be obtained. A reduction in coal consumption from present averages to 0.8 pound per kwhr would mean a savings of about one mill per kwhr. At an average coal consumption of 0.6 pounds per kwhr, the savings would become 1½ mills per kwhr.

For the purpose of this survey, a power rate of 9 mills per kwhr has been assumed. This optimum rate was determined in cooperation with utility sponsors. However, it should be emphasized that rates for any individual location are influenced by many divergent factors. Thus, for any actual or proposed steel plant location, a separate analysis is required.

All in all, it appears that future trends in electric power costs on a 1951 dollar basis might very well be downward, or, at worst, horizontal.

COMPARISON OF OPEN-HEARTH AND ELECTRIC-FURNACE STEELMAKING COSTS OF THE FUTURE

A comparison of predictable future steelmaking costs of plain carbon steels made by the open-hearth or the electric furnace process must distinguish between nonintegrated plants which must purchase pig iron on the open market and large integrated steel plants producing their own pig iron. The integrated steel plants form the backbone of the steel industry in the United States and account for over 90 per cent of the low carbon steel tonnage produced in this country.

For the nonintegrated plants operating on a cold metal charge, a comparison of open-hearth and electric furnace steelmaking costs, estimated at the 1952 level of prices for materials and labor, is shown in Table VIII.

TABLE VIII

Comparison of Steelmaking Costs for Nonintegrated Open-Hearth and Electric-Furnace Steel Plants at 1952 Level of Prices for Materials and Labor

	Open-hearth plants of indicated annual capacity			Electric-furnace plants of indicated annual capacity		
	250,000 Tons of ingots	500,000 Tons of ingots	1,000,000 Tons of ingots	250,000 Tons of ingots	500,000 Tons of ingots	1,000,000 Tons of ingots
Cost of metallics (less recoverable scrap)	$46.65	$46.65	$46.65	$42.95	$42.95	$42.95
Cost above	$18.09	$16.52	$15.23	$18.59	$17.07	$16.26
Production costs per ton of ingots	$64.74	$63.17	$61.88	$61.54	$60.02	$59.21
Difference in steelmaking costs for equivalent plant capacity	.....	.....	.....	$ 3.20	$ 3.15	$ 2.67

TABLE IX

Comparison of Steelmaking Costs for Integrated Open-Hearth and Electric-Furnace Steel Plants at 1952 Level of Prices for Materials and Labor

	Open-hearth plants of indicated annual capacity		Electric-furnace plants of indicated annual capacity	
	500,000 Tons of ingots	1,000,000 Tons of ingots	500,000 Tons of ingots	1,000,000 Tons of ingots
Cost of metallics (less recoverable scrap)	$41.08	$41.08	$40.18	$40.18
Cost above	$13.95	$12.93	$15.95	$15.14
Production costs per ton of ingots	$55.03	$54.01	$56.13	$55.32
Difference in costs for equivalent plant capacity	.....	.....	+$ 1.10	+$ 1.31

A similar comparison for integrated plants operating on a 50 per cent hot metal charge is shown in Table IX.

From earlier discussions, average increases in fuel costs for open-hearth operations may increase by as much as 50 cents per ton of ingots. At the same time, a reduction in power costs of up to one mill per kwhr may be possible, which would again favor the electric furnace by about 50 cents per ton of ingots.

If these gains in comparative costs for the electric furnace can be realized, it can be seen that local conditions should almost certainly govern the type of plant to install.

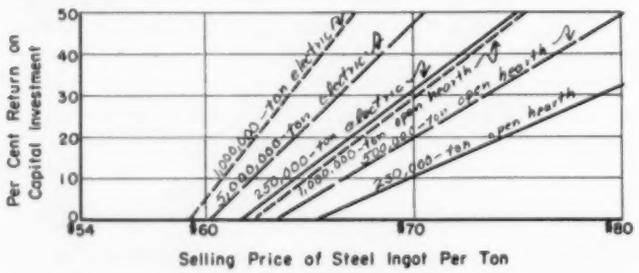

Figure 5 — Return on capital investments for open-hearth and electric-furnace shops (cold-melt operations) at various selling prices for steel ingots.

COMPARATIVE RETURN ON CAPITAL INVESTMENT

This study was not intended to include detailed considerations of capital structure problems in the steel industry. Before concluding, however, some mention should be made of the potential returns on capital investments for each of the steelmaking processes at various assumed values or selling prices for steel ingots.

Figure 5 shows the potential returns on capital investment for the various sized electric furnace and open hearth shops, assuming cold melt operations. The figure shows that the electric furnace shop of any of the capacities studied should yield a higher rate of return on capital investment than even the 1,000,000-ton open-hearth shop at any assumed selling price for steel ingots. At assumed selling prices for ingots of $63 and $66 per ton, the returns on capital investments for the various sizes studied would be as given in Table X.

TABLE X

Cold-melt practice	Percentage return on capital investment sales price of ingot	
	$63/Ton	$66/Ton
Open-hearth shops		
250,000 tons annual capacity	Net loss	2
500,000 tons annual capacity	Net loss	8½
1,000,000 tons annual capacity	3½	15
Electric-furnace shops		
250,000 tons annual capacity	5	16½
500,000 tons annual capacity	14	28
1,000,000 tons annual capacity	24	43

It should be noted that the average production costs of steel ingots for all cold-melt shops as estimated in this study are higher than quoted prices of $54 per ton at Pittsburgh and $56 per ton at Detroit[10]. On the other hand, they are substantially below the quoted price of $81 per ton at Fontana[10]. This points up the necessity of making a careful appraisal of existing and potential conditions at any individual location before any final decision can be reached regarding the feasibility and type of steel plant which would be most advantageous to the investor.

Figure 6 shows the potential returns and capital investment for the various sized plants studied, using 50 per cent hot metal and 50 per cent scrap charge. Although the production costs for electric furnace shops are higher than those for open hearth of equivalent size, the lower capital investment permits an improved

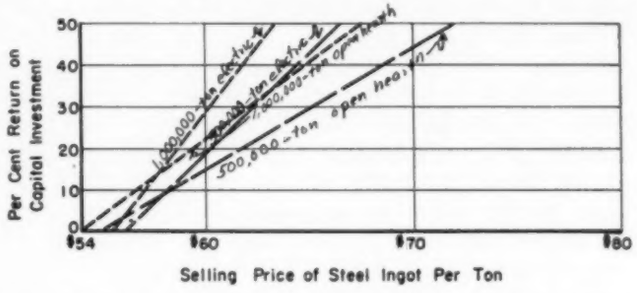

Figure 6 — Return on capital investments for open-hearth and electric-furnace shops (50 per cent hot metal) at various selling prices for steel ingots.

percentage return as the spread between cost and selling price increases.

The potential returns on capital investment at various assumed selling prices for steel ingots are given in Table XI.

TABLE XI

50-50 Hot-metal practice	Percentage return on capital investment sales price of ingot			
	$54/Ton	$56/Ton	$58/Ton	$62/Ton
Open-hearth shops				
500,000 tons annual capacity	Net loss	3	9	21
1,000,000 tons annual capacity	0.5	8	15	30
Electric-furnace shops				
500,000 tons annual capacity	Net loss	Net loss	9	28
1,000,000 tons annual capacity	Net loss	3	16	41

This table shows that the estimated production costs of electric furnace and open hearth shops are so close that, where high rates of return on capital investment are desired and possible, serious consideration should be given to an examination of local conditions before reaching a final decision as to the type of plant to install.

A final word of caution should be expressed. Throughout this entire study, the cost figures presented are those estimated for full scale operations. It was beyond the scope of the study to attempt to analyze in detail the extent and nature of cost changes that might be expected from lower scale operations. Various items shown in "cost above" undoubtedly would differ by varying degrees, but the fact that fixed costs for the open hearth are the largest single item in "cost above" and are some ⅔ greater than those for the electric furnace would indicate that lower scale operations might well favor the electric furnace. Also, under lower scale operations, the much greater flexibility of the electric furnace should prove valuable in holding down increases in many other "cost above" items. The overall increase would be offset to some degree by the higher unit electric power costs for electric furnaces operating at low load factors or reduced volume because of the minimum revenue requirements in most power contracts.

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DISCUSSION

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C. E. Williams: The rapidly growing production of carbon ingots in electric furnaces in this country makes the report a timely one; and it will undoubtedly stimulate additional interest along these lines.

In the case of cold charge plants, the report indicates many noteworthy improvements in production rate and cost reduction achieved with the modern, top-charged electric furnace in recent years. The reported ingot costs reflect this progress and its competitive position with the cold charged open hearth has been substantially improved.

In the case of hot metal plants, the report indicates

that the cost comparisons are based on the premise that high hot metal charges in electric furnaces are feasible even though there is no important established background for this practice at the present time. The reported cost comparisons must therefore be accepted with some reservations. Since the feasibility of this practice has not been widely demonstrated, it leads to a question whether or not high hot metal charges are practicable in electric furnaces; and if so, what range of metal percentage can be best employed.

The report assumes the use of a 50 per cent hot metal charge for both the electric furnaces and the open hearth. While this percentage of hot metal may or may not actually represent a desirable electric furnace charge, it is considerably lower than would be desired in an open hearth plant. If we increase the metal percentage to suit the open hearth, purchased scrap requirements will be reduced and greater quantities of by-product fuels will result from the increased iron and coke production. The higher metal charge is favorable to open hearth productivity and is more economical because of lower cost metallics and the availability of additional by-product fuels for melting. In the case of electric furnaces, it may be argued that these units can use the same range of metal percentage in the charge as the open hearth. This is somewhat more doubtful, but even if it could, it will have the additional problem of utilizing by-product fuels since they cannot be used directly for melting as in the open hearth. Some of these fuels may be sold or they may be used for power generation. The cost of power generating facilities is about $250 per kw at most steel mill locations and in this event, the total cost of the electric furnace plant may equal or exceed that of a comparable open hearth.

In the case of the open hearth, waste heat boilers may also be contemplated to minimize fuel costs and provide a portion of plant steam requirements. Steam produced in modern boilers from open hearth waste gases form the basis for substantial savings.

Cost above—The total "cost above" in each of the reported comparisons is lower for the open hearth because of power and electrode costs in electric furnaces. Most items in the "cost above" comparisons appear to be representative but a few require some further comment.

The report assumes that purchased melting fuels will be used with a 50 per cent hot metal charge in both operations. Open hearth fuel oil in the report is priced at $0.60 per million Btu. Present prices are substantially lower.

The report assumes the use of 10 pounds of fluorspar per ton of open hearth ingots and zero usage in electric furnaces. Experience indicates that 3 to 4 pounds per ton is ample in the open hearth and probably the same amount may be required for the electric furnace.

Investment and capital costs—The investment cost of an electric furnace plant, excluding power generating facilities, is indicated to be about 60 per cent of the investment cost for a comparable open hearth. The cost per annual ton of capacity for a 1,000,000-ton plant for instance is reported to be $15.90 compared with $26.65 for the open hearth. As a result of this difference, the reported capital or "fixed costs" per ton heavily favor the electric furnace. Fixed costs are defined in the report as a summation of amortization of plant facilities, taxes and interest on the capital investment. It is assumed to equal 12 per cent of the investment cost per annual ton of capacity. This 12 per cent seems high if the plant is to have a normal life expectancy, and if present interest and property tax rates are assumed. A lower percentage of capital investment may be sufficient in many cases if it includes only the indicated items. The higher cost open hearth will benefit most from such reductions.

Ingot yield—Estimated ingot yields of 91 per cent and 89 per cent respectively for electric furnace and open hearth cold charge plants are acceptable. It should be pointed out that a large part of this difference is due to non-metallics in the charge, resulting from the higher percentage of pig iron used in the open hearth. In the case of hot metal plants for both processes, the yields stated in the report are 88 per cent and 87 per cent respectively in favor of the electric furnace. The gross metallic charge reported for the open hearth however, totals 2,351 pounds of scrap, hot metal, Fe in ore and additions compared with 2,288 pounds per ton for the electric furnace. This is a difference of 63 pounds per ton of ingots or about 2.3 per cent in ingot yield for essentially identical charges. A 1.0 per cent difference in yield might be expected as stated in the text. This would amount to about 25 pounds per ton of ingots.

Price relationship of charged metallics—The assumed prices of steel scrap and pig iron in the report are based on late 1952 prices for eastern Pennsylvania as listed in *Iron Age* magazine. These prices were taken during a period of all out demand for metallics with the consequence that dollar differences between the price of these materials and hot metal cost are much greater than would be indicated during periods of lower demand. Since this relationship changes with operating rates, hot metal is favored during periods of high production and purchased metallics are favored during periods of depressed operation. The plant is expected to operate for many years, and it might be desirable to consider differences in material costs and prices for a period approximating the life of the facilities. If this is done, the difference in net metal cost between a cold charged electric furnace and a cold charged open hearth is substantially reduced. In the case of the hot metal plants, the resulting difference in net metal cost of the two processes is of a minor nature due to similarity of the charges.

Other considerations—The electric furnace has an inherent advantage over the open hearth for production of very low sulphur steels since electric power is used for melting.

The effect of heat size on inventories at low operating rates favors electric furnaces over the larger open hearth furnaces. Smaller heat size can be used to advantage to meet a variety of small orders and requires a lesser amount of steel to be placed in stock.

During periods of low or declining operating rate, cost above will increase in both operations, but the difference will favor the electric furnace, particularly in the item of fixed cost if we exclude power generating facilities.

Summary and conclusions—The cold charged electric furnace has improved its competitive position with the open hearth through the use of larger units, top charging and other developments. Until the feasibility of high hot metal charges in electric furnaces has been more extensively developed, actual ingot costs may be more or less favorable than the reported costs. In the case of the open hearth, some inherent advantages of the process have not been indicated in the report and the resulting cost comparisons represent less favorable conditions than will exist in a more balanced operation.

H. W. McQuaid: This report leans over backward, and is conservative, in my opinion as regarding the modern electric furnace, because when you put in a new electric furnace or a new open hearth for that matter, you do not base your calculations on what the average has been for the last 15 years on door charge electric furnaces; you pick out what the really modern electric furnace can do.

When you are talking carbon steel, there are all kinds of carbon steel, and there are all kinds of methods of producing it, but there is a difference between the carbon steel plant and the alloy steel plant when it comes to making steel in the electric furnace. Some of the best electric furnace shops in this country are shops that are very little known. An example is Connors Steel in Birmingham, that makes a commercial carbon steel product like cotton tie directly from electric furnace billet type ingots and they make it at a cost that not only is as good, but better than one of the large steel plants that has every facility in the world for making cotton ties. They have blast furnaces, coke ovens, lime kilns and everything else, but each of the 12-ton electrics down at Connors make heats every two hours, and they roll them on a mill direct from the billet type ingot to the cotton tie in one conversion. I have seen the costs of both plants and studied them very carefully.

The question before the house, it seems to me, is not what the cost of fuel is or what the cost of anything else is, it is what the cost of the final product is. Sometimes it pays to take the investment that would normally go into coke ovens and blast furnaces and put them into finishing equipment, because the mills that have the best finishing equipment are the mills that make the most money. The question of investment is probably the most important single factor in whether you are going to put in electric furnaces or open hearth.

If you are going to make carbon steel I think of semi-killed and rimmed steel, and not special requirement forging quality 1040 axle shaft stock, because they really are alloy-grade carbon steels and require alloy thinking. However, the difference in thinking between men working on electric furnaces, producing carbon steel of the rimmed grade and semi-killed type merchant bar is altogether different than the men on the higher quality alloy steels.

The primary factors in making cheap steel in the electric furnace and making it so that it compares—not only favorably but more than favorably with any of the open hearth plants whether integrated or not, is the incentive that you pay the men in the shop and how modern your equipment is. You can not compare door charge electric furnaces in your thinking with open hearth and expect to get anywhere. The modern electric furnace carbon steel plant represents a top charge furnace, with plenty of electrode capacity, plenty of power input, and if they do not make six heats a day, there is something wrong.

In this report they were figuring on three 18-foot shells to make 250,000 tons a year. I am figuring on a furnace plant to do exactly the same thing now, and I can assure you there will not be more than two furnaces there, and they will make more than 250,000 tons a year of carbon steel. This is because the melting capacity will be there, the incentive rates will be high enough, and the men's thinking will be always on how many tons per hour they are going to get out of the melting furnace.

J. R. Miller: The relative merits of electric furnace and open hearth smelting have been the subject of many discussions at these meetings in recent years. While there has been a definite area of general agreement that the modern electric furnace can be used as an effective steel production unit, there have also been differences of opinion expressed as to its ability to compete successfully with the open hearth. Mr. Moore's paper, and the larger study on which it is based, brings the past discussions on the subject up to date and may help to resolve some of these differences. In addition, we must acknowledge the very fine development of the trends of future fuel costs as a valuable new contribution to the discussion.

One could try, if he wished, to question some of the individual figures given in the paper. I do not propose to do this. Notwithstanding a definite but understandable tendency towards conservatism that is found in such estimates, I believe that it may be agreed that the general magnitudes of most of the individual figures, insofar as they are based on available data and practice, appear to be logical.

Instead of discussing these figures, I would like to comment on some of the implications which follow from Mr. Moore's report.

First, and as a general consideration, the paper confirms—or reconfirms—the fact that the electric furnace has definitely "come of age." As such, it is entitled to its own "long pants" rather than "hand-me-downs" from an older brother. Many present electric melt shop layouts are, at best, modifications of good open hearth plants which do not make possible the fullest realization of the electric furnace capabilities. At the same time, a large majority of the furnaces are grossly underpowered, and a good number of them are still door-charged. Most of the units now in operation could show increases in their production rates, and there is no reason why rates comparable to the 18.8 tons per hr used in the paper for 20-ft furnaces should not be reached and even exceeded. We can infer from the paper that there are in operation today a considerable number of electric furnace plants which can gain much in terms of reduced production costs and increased furnace output by changes in shop layout and furnace transformers, at unusually low capital cost per ton of increased capacity.

Secondly, and particularly in connection with the comparison between all-scrap open hearth and electric furnace operation, the paper suggests the conclusion

that the cold metal open hearth is rapidly becoming, if it is not already, obsolete. There is presently a substantial tonnage of carbon steel being produced in such units. Exclusive of the West Coast there are at least fifteen cold metal open hearth plants with annual capacities of from about 250,000 to over 500,000 tons, pouring nearly 6,000,000 tons of basic steel ingots from 95 furnaces. A third of these are in sizes under 100 tons; of the remainder, the 17 largest are between 150 and 165-ton capacity. Mr. Moore's figures indicate that substantial savings may be effected at such non-integrated operations through the installation of electric furnaces. Such savings may equal nearly $1,000,000 a year in production costs on 250,000 tons of ingots and this may represent the differences between profitable operations and financial difficulties in the more competitive periods which may be anticipated in the near future.

My third comment refers to the heart of the electric furnace vs open hearth discussion which, of course, lies in the consideration of both furnaces operated with hot metal. Actual operations confirm Mr. Moore's figures that there is a substantial advantage in cost-above enjoyed by recently designed open hearth shops over today's best electric furnace plants. The former reflect the most modern developments in open hearth engineering and practice, and their operating costs approach the limit of open hearth potentiality. Cold metal electric furnace output and costs may be improved somewhat by increased furnace diameter and transformer sizes, and by better shop layouts, but it seems clear that the best modern open hearth with hot metal will have a $3.50 to $4.50 lower operating cost than a comparable electric furnace plant on all-cold charge. The degree to which this differential might be reduced through the use of hot metal in the electric furnace, particularly in view of its greater flexibility and lower capital cost requirements is today of direct interest to nearly everyone active in the industry, be he in management, operation, or engineering.

In this respect, Mr. Moore's paper is of much value with its presentation of a general up-to-date comparative analysis of the two operations with hot metal. However, it suffers from the same shortcoming that has been apparent in several similar papers which have been presented in the past two or three years in that the electric furnace data are largely hypothetical. This is, of course, not the fault of Mr. Moore or his associates, but we have to know the answer to a number of important questions more specifically. Among these are such apparently "simple" questions as:

"What changes in practice may have to be made?"

"How long will it take to pour some fifty tons of hot metal into the furnace?"

"How will the use of oxygen affect meltdown and refining times?"

"What will the presence of a more active slag do to the furnace lining, and how will this affect tap-to-charge time?"

I mention only those factors which apply to the overall question of furnace heat time for a hot metal and scrap charge as compared to an all-scrap furnace, and these are just a few of the many which have to be known with as much practical precision as possible. Lacking sufficient actual operating data at this time, this sort of analysis, based on known metallurgical and thermodynamic considerations, needs to be worked out for electric furnace heats with hot metal as a supplement to this otherwise very complete study. Such an analysis would be particularly valuable since it seems to me that the paper indicates a general equality between the electric and open hearth processes with some advantage for the electric furnace implied primarily on the basis of a number of intangibles. Should the further analysis indicate as little as a 10 per cent reduction for the hot metal heat rather than the equality with a comparable all-scrap heat assumed in the study, it would obviously affect the conclusions that can be drawn from Mr. Moore's report. For in such an event, the case for the electric furnace would not merely have to be inferred, but could be stated quite firmly and definitely.

These discussions have reached a point where the generality—that is the feasibility of the electric furnace—is more or less definitely accepted. The paper we have just heard is a good point of departure from which to proceed further into the subject.

W. M. Farnsworth: Contrary to some of the data in the report, it does not indicate that the electric furnace can compete with the open hearth for the major part of the nations steel production. Outside of those closely connected with the industry, probably few people fully appreciate the potentialities of the electric furnace. The study reveals that under certain conditions and in certain locations there are many factors favorable to the electric furnace. Advancements in electrical equipment construction and operation, using single slag practice, have made it more attractive for the production of low carbon steels. The report cautions that the entire analysis should be used mainly as a guide for comparable sudies that are based on actual data for a given set of localized conditions. The study is concerned with low carbon steel, and not with the high grade products which will always be of greatest importance to the electric furnace industry in this jet and atomic age.

Recalling some experiences on one of the first electric furnaces in this country, several years before World War I, the demand for better quality steel was just as pressing then as it is today. That was before the advent of stainless and high heat resistant steels which could never have been developed without the electric furnace. This new tool provided means of handling certain chemical combination not possible in any other steelmaking processes. We had much to learn in putting it to best use. Some of the theories and ideas handed down from crucible practice did not produce very good results when applied to the electric furnace. At that time molten metal was taken from the bessemer or open hearth because the cost of electrodes and electric energy was considered too high to melt from a cold scrap charge. During World War I, many high grade carbon and alloy steels were produced for bearings, guns and other special applications. It was then the electric furnace demonstrated ability to produce consistently high quality steels. Many of the same steel analyses are used today. Stainless and heat resisting steels created an important market, and now aircraft and jet engineers are

continuing to develop even more super steels which only electric furnaces can produce.

Since the last war, the demand for carbon steel promoted high operating rates. Large tonnages of so called conversion ingot have been produced. Using single slag practice, the large high-powered, top-charge furnace achieves materially lower operating costs.

In comparing economics of the open hearth and electric furnace, the Battelle report covers two different practices; complete cold charge and 50-50 hot metal and scrap.

With respect to cold charge practice, cost above is estimated at 55¢ and $1.03 higher for the electric furnace. Lower fixed charges and other cost savings are not enough collectively to offset the higher cost of electric energy and electrodes. In calculating the cost of metallics, the electric furnace is favored principally because of the difference between the cost of scrap and pig iron. The market price of pig iron which must bear the cost of pigging and extra handling is much higher than molten iron from the blast furnace. The cost of metallics is variable and can fluctuate widely in different sections of the country. The balance between the market price of scrap and pig iron can greatly affect the economics in either direction.

Assuming that electric furnaces eventually replace all present cold charged open hearths, important new demands would be created for electric energy and other equipment. In the overall tonnage, open hearth hot metal practice predominates by a large margin and in this field the economics are not in favor of the electric furnaces.

Fontana and Lorain pig iron coupled with the modern open hearth will dominate the steel industry, and steel plants in the lower lake regions will continue to be open hearth hot metal plants for the foreseeable future. The use of hot metal in the electric furnace is no doubt feasible but it is not believed to be the best combiner of pig iron, ore and scrap.

At the Republic Steel Corporation, South Chicago plant we have nine 20-ft diameter furnaces. Two of the furnaces are top charge and powered with 20,000 kva transformers, the other seven are door charged with 12,000-kva transformers. The top charge furnaces each produce 4,000 to 5,000 tons of ingots per month more than the door charge furnace. They do not however compete favorably "cost wise" with the 200-ton open hearths on 55 per cent hot metal practice in the same plant.

When the scrap market justifies, the electric furnace can be used to best advantage for carbon steels, but its greatest value is in its ability to make consistently high grade products. In this field the need for uniform quality precludes any compromise for the sake of cost.

David D. Moore: It is interesting that comments and criticisms of the study appear to be about equally divided between ones considering the findings to be too conservative and ones considering them to be too optimistic.

In making the study, it was recognized that any individual cost figures shown would be criticized as being either too high or too low, depending on the location and operating methods of individual companies. Wide variations were found in individual cost items as reported by various companies contacted in making the study. These cost figures were reworked to form what is believed to be reasonably representative amounts. As pointed out in the paper, actual costs at any plant probably would vary from those used in the study, depending on factors such as location, design, and fuel and electric power costs. The small differences in comparative costs point up the need to examine local conditions before reaching a final decision as to the comparative economics of the two processes.

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MODERN ARC

. . . . increased use of arc furnaces for steelmaking has been largely dependent upon a number of advances in electrical equipment . . . .

▲ MUCH attention currently is being given to the increased use of the electric arc furnace as a prime tool for the making of not only alloy steels but normal grades of carbon steels. Since such is the case, the electrical equipment associated with a modern arc furnace and the practices presently prevailing, and those which will prevail in the future are being attended renewed consideration.

The arc furnace, of course, is not a new tool just coming into use in the steel industry, since it has a history of application in the United States for the making of steel which dates back almost a half century. The first furnace for the arc melting of metal and the production of steel was installed in the United States in 1906. Through the period which has followed, the arc furnace has been producing steel at an ever increasing rate in comparison on a year-to-year basis with other steelmaking equipment and processes.

The years just prior to, during, and immediately after World War II resulted in an unprecedented increase in the use of electric arc furnaces. Generally, the opinion had been formed that, as a producer of high grade alloy steels, the arc furnace had no peer; but as a producer of normal grades of carbon steels, the operating costs were higher per ton than those obtained through use of the open hearth process. However, the last five years have given rise to indications suggesting that perhaps the arc furnace had not reached its peak of economical production in comparison with other forms of steelmaking, and that this process had a bright future as well as a bright present and past. Improvements in all phases of operations have resulted in a situation wherein the arc furnace is challenging the open hearth process for a not-too-small portion of the country's carbon steel production.

TRENDS IN THE USE OF FURNACE ELECTRICAL EQUIPMENT

Figure 1 is the familiar graph showing the increase in the country's electric furnace steel producing capacity over the years from 1938 to 1953 with 1953 being estimated only. Since the end of the war in 1945, electric furnace capacity has increased about fifty per cent.

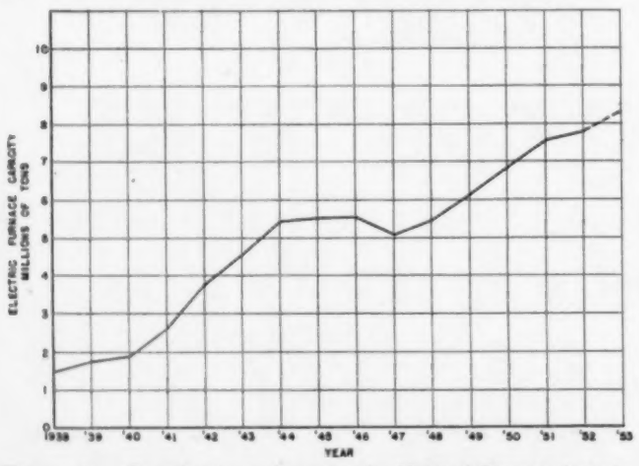

Figure 1 — Graph shows increase in United States electric furnace steel producing capacity.

Figure 2 relates to inquiries directed to electrical manufacturers for arc furnace equipment over the years extending from 1946 to the end of 1952. These curves indicate generally the number of furnace installations contemplated for a given year and the aggregate yearly megavolt-ampere ratings of furnace transformers for such proposed installations. It will be noted that activity was extremely high in the years 1950 and 1951. During these two years, a total in excess of a half million kva of electrical equipment for arc furnaces was being given serious consideration by steel producing activities. Had all this contemplated increase in installation of furnace equipment been carried through to actuality, it is estimated that perhaps as much as two million tons per year increase in capacity of steel production would have been the result. However, not all the considered applications were carried to fruition—it being estimated that only thirty to forty per cent resulted in actual working furnaces coming into production in 1951, 1952, and 1953. This would increase the production capacity for electric furnace steel by almost a million tons per year.

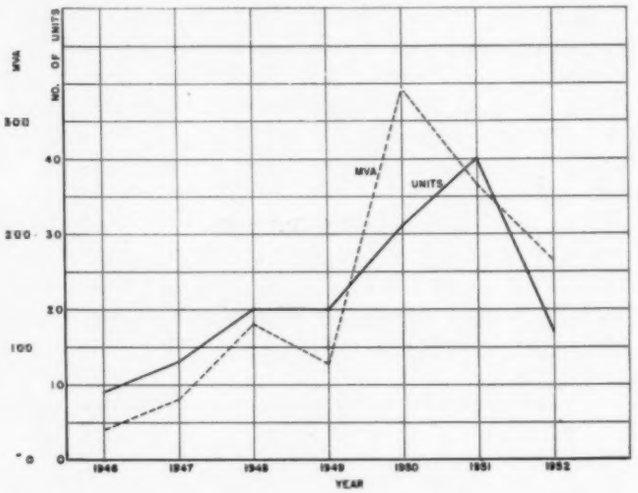

Figure 2 — Graphs based on inquiries directed to electrical equipment manufacturers show contemplated new installations of electric furnaces and aggregate yearly megavolt-ampere rating of furnace transformers.

Another point of interest is a breakdown regarding the types of steel producers installing new electric furnace equipment. In the greater number of cases, new furnaces have been added by smaller producers either

FURNACE EQUIPMENT AND PRACTICES

By E. H. BROWNING
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increasing the electric furnace capacity in their shops, or else entering into the electric steel production field for the first time. The larger producers of electric furnace steel have in some cases added new equipment and in others have revamped their existing equipment to increase its production capabilities. There have been quite a number of electric furnace transformers rewound in recent years, such that higher secondary voltages are obtainable with attendant increases in kva capacity. Thus, quite a few furnaces installed in the early nineteen forties have been revamped mechanically and electrically, such that increases in production capabilities of twenty to thirty per cent have been realized in some cases.

Today electric furnace costs per ton of steel produced reportedly compare with open hearth production costs. Lowering of production costs has occurred as a result of close attention being paid to improving operating procedures involving material handling, scrap preparation, charging methods, effective use of electric power for melting and refining, increase in size of electric furnace heats, metallurgical techniques, and to other economics resulting from lowering of initial equipment and maintenance costs. Our principal interest here, in regard to economic improvements, is based on the lowering of the initial cost per kva of installed capacity as the sizes of furnaces have increased. Also, consideration is given to the effect of increases in production rates which have come about by virtue of increases in the amount of power which can be put into the charge.

COMPARATIVE ELECTRICAL EQUIPMENT COSTS

Figure 3 gives a plot of the range of present day electrical equipment costs in dollars per kva rating against the arc furnace rating. The spread in the cost for a given furnace size is accounted for by variation in the special features of construction of the transformer, control and switchgear apparatus associated with different furnaces. It is readily noted that as the size of the furnace increases, the cost per kva of the electrical equipment decidedly is reduced. The electrical equipment for a 10,000 to 12,000 kva furnace—the ordinary large size installed ten to fifteen years ago—averages about eight dollars per kva, while that for furnaces of the order of 25,000 to 36,000 kva which are being installed in industry today, average approximately a dollar and a half less per kva.

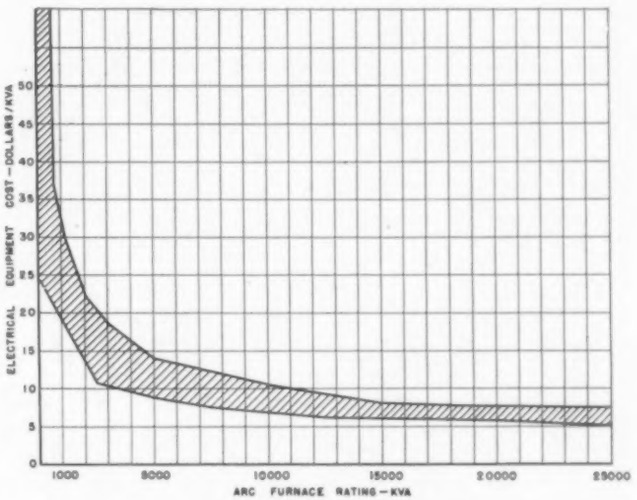


Figure 3 — Graph illustrates cost of electrical equipment versus arc furnace rating.

EFFECT OF HIGHER SECONDARY VOLTAGES

The ability to utilize the larger sizes of arc furnaces met with today has to do largely with the advances made in the supplying of power through the electrodes of the furnace to the charge.

Figure 4 illustrates the trend in the use of larger sized furnaces for ingot steel production. The main factor permitting use of larger kva ratings for the melting operation stems from the use of higher secondary voltages in the melting-down phase of the heat. The upper curve of Figure 4 shows that prior to 1920 the highest secondary voltages used on steelmaking arc furnaces were of the order of 110 volts phase-to-phase. This voltage value was increased over the next twenty some years into the early nineteen-forties, until it was approximately 300 volts. At that particular time, it appeared that furnaces of the Heroult type employing three electrodes had reached their maximum size as limited by secondary voltage safety considerations, as well as the amount of power which could be transferred through the arc to the charge under and around an

electrode. Since the transmission of the power from the furnace transformer to the electrodes requires large sections of copper with attendant unavoidable electrical loops, the inherent reactance of the furnace circuit had reached values which made it impossible to introduce more power into the furnace charge by increasing the circuit current. Actually, as has been pointed out many times, increase of arc current beyond a certain value for a given furnace circuit results in a decrease of power input to the metal to be melted. One way for increasing melting rates by introducing greater amounts of power to the charge was that of operating electric furnaces at secondary voltages in excess of any value known at the time. Therefore, in 1947 an installation was made having the highest secondary voltage established at 445 volts—a value not believed practical five years previous. At the present time, electrical equipment is in process of manufacture which will permit furnace secondary voltages in excess of 500 volts to be used for melting down steel. The lower curve of Figure 4 shows what this has meant in an increase in size for ingot steelmaking furnaces. It can be seen that prior to 1920, the usual large size furnace used for steel making operations was less than 5000 kva. This maximum rating increased in the next quarter century and reached a value shortly after the war of 15,000 kva. With the use of much higher secondary voltages, ingot steelmaking arc furnaces are now rated in the largest

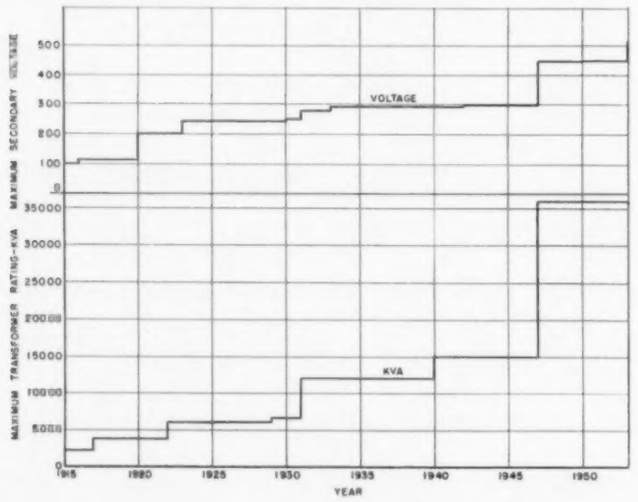


Figure 4 — Graphs show progressive increases in transformer secondary voltages and ratings used in the steel industry.

size in excess of 25,000 kva. Such furnaces are capable of producing heats as large as 150 tons, which gives pause for thought that not only may the electric arc furnaces be approaching open hearth furnaces from a production cost standpoint, but also from the standpoint of actually being able to turn out nearly as large heats.

RELATION OF FURNACE RATINGS

Figure 5 gives plots relating present-day furnace size as expressed in inside shell diameter, the approximate average pouring capacity, the furnace transformer rating and the top secondary tap voltage used. Generally, new installations falling below the 11 to 13-ft shell diameter are utilized mainly by foundries for the production of steel for casting, whereas those above this size up to the nominal 24-ft shell diameter size are utilized by the basic ingot producing steel industry. The top limits for voltage, kva rating, and pouring capacity shown by this graph are those which are ex-

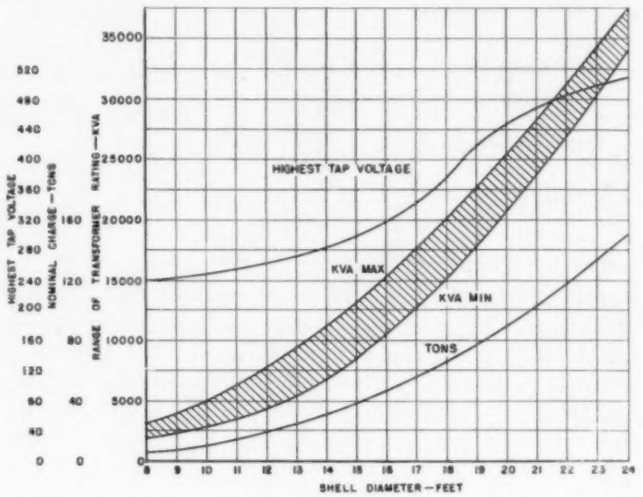


Figure 5 — Graphs relate ratings applied to electric furnaces and indicate nominal values of secondary voltages used.

isting at the present time, and it is quite likely that the near future will see even larger sizes being built and installed. At least one attempt has been made to increase electric furnace size by the use of six electrodes, and it is evident this operation, which was initiated over fifteen years ago, has met with some degree of success. It quite conceivably could happen that the near future will see some radical design changes in furnace structures and arrangement of equipment as well as in operating techniques associated more directly with types of material charged.

Electrical equipment used with arc furnaces has undergone a period of progressive development and has kept pace with the growing demands of industry. As may well be expected, increases in size and rating of furnaces have accentuated problems associated with the design and application of switchgear, transformers and regulating equipment.

FURNACE TRANSFORMERS

Transformers used for supplying arc furnaces are generally specially constructed to meet the very severe conditions under which they must operate. They must be well braced to withstand the repeated and tremendous mechanical stresses caused by current surges resulting from characteristic arc furnace operation. Special design considerations must be given to conveying the very high winding currents—which extend well up into the tens of thousands of amperes—so that uniform distribution and reduced losses can be effectively realized. Although the sizes of furnace transformers have by no means reached an upper limit, special consideration and study are presently being given to possibilities of modifying the core and coil assembly and

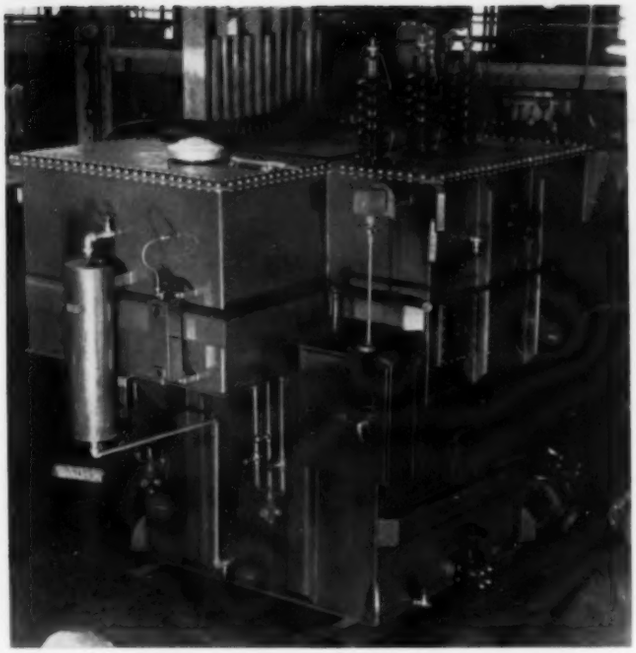


Figure 6 — View shows a typical oil-immersed, water-cooled, shell form furnace transformer.

tank designs to obtain smaller sized units and to improve cooling means.

Figure 6 shows a typical oil-immersed, water-cooled, shell form furnace transformer with accessory equipment in evidence. Advances have been made in the methods employed for bringing the low voltage, high current bus bar from the core and coil assembly of the unit through the top cover of the tank. Gas-tight bus bar seals are presently being used between the bar leads and the cover to prevent the entrance of foreign materials and moisture carried in the air. Since moisture in the oil of a transformer can result in damage to the insulation and failure of the transformer, dehydrating breathers are also placed on the transformer to permit "in-breathing" and "out-breathing". During "in-breathing", air passes through the dehydrating material and only dry air is allowed to pass into the tank. During "out-breathing", the air by-passes the dehydrating material and passes from the tank into the atmosphere. It is becoming general practice nowadays to equip furnace transformers with thermosiphon oil conditioners to effect a continuous treatment of the oil to insure good values of dielectric strength, power factor, interfacial tension and neutralization. This oil conditioner unit is connected into the tank of the transformer with the inlet being placed just under the minimum oil level, and the outlet being placed at the bottom of the tank. Thus the transformer oil circulates through the conditioner due to a thermosiphon action with hot oil flowing in at the top and through the activated material, and thus to the bottom of the transformer. The activated material removes moisture and organic acid as well as other impurities from the oil during its flow. As long as the transformer remains excited, the conditioner will operate to maintain the desired oil characteristics. With such equipment, periodic tests of oil samples should be made approximately every six months and if any trend of degeneration of the oil is noted, the conditioner should be replaced.

Other accessory equipment employed with a furnace transformer includes the mechanical relief device for permitting release of any abnormal pressures built up within the transformer tank, temperature indicators either of the dial type or of the Wheatstone bridge type, magnetic liquid level gauges and flow gauges.

Tap changers used with arc furnace transformers in this country are of the motor-operated, no-load type, and are supplied as an integral part of the transformer. In the past, the tap changer was located in the transformer tank directly above the core and coil assembly, but in recent years it has become the practice with shell form transformers to provide an extension on the side of the transformer tank and mount the tap changer within this enclosure. Generally, tap changers having four positions or six positions are provided. A typical tap changer will be arranged to do the necessary delta-wye switching in order that a range of voltages necessary for the making of a heat of steel is available. Of course, many more taps are provided on the transformer than are connected to the tap changer equipment in most cases. By means of a link type terminal board installed inside the transformer and accessible through a manhole, the selection of the proper tap for a given position of the tap changer can be made simply by proper arrangement of the links. The operating mechanism used to drive no-load type tap changers is mounted on the side of the tank near the tap changer compartment. This operating mechanism consists of the tap changer driving motor and the mechanical transmission system along with the interlocking switches. Normal practice to date is to provide interlocking switches such that the transformer tap changer cannot be operated unless the furnace circuit breaker is in the trip position, and conversely the circuit breaker cannot be operated unless the tap changer is on a definite tap position. Further interlocking for safety's sake consists of using key type interlocks between disconnect switches, the circuit breaker, and the tap changer mechanism cabinet to insure absolute safety for maintenance personnel.

FURNACE CIRCUIT BREAKERS

Much progress has been made in recent years in the design and application of circuit breakers to arc furnace circuits. It is well recognized by the steel industry and the elecrical manufacturers that the role played by the circuit breaker in the furnace circuit is one demanding rugged equipment requiring minimum maintenance. A circuit breaker utilized in conjunction with an arc furnace must serve as an interrupter of normal and overload currents and perform this function as many as 3000 times per month. In addition, the circuit breaker must be prepared at all times to provide primary circuit fault protection for the transformer and other installed equipment. Oil breakers were used in the past for performance of this duty, and in some instances are still employed today. However, oil carbonization and the resulting deposits of conducting material on the insulated members of the breaker generally require that the breaker be maintained quite frequently with the attendant high maintenance cost.

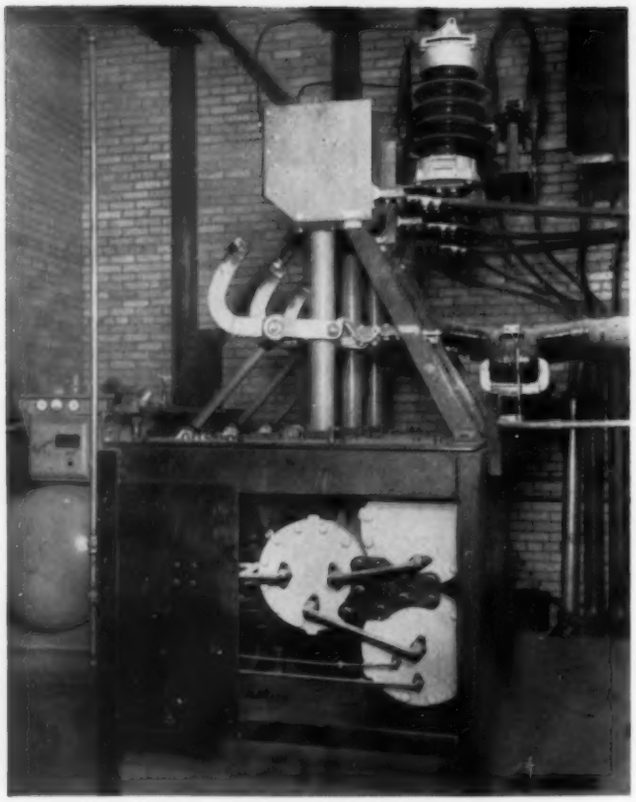


Figure 7 — This circuit breaker was developed for arc furnace duty.

Magnetic air breakers have been utilized for some time now as a definite improvement over the application of oil circuit breakers. These magnetic air circuit breakers are generally of the drawout metalclad type, the same as are used in general power circuit applications. As furnace sizes have continued to increase, more and more installations have been made with the furnace transformers supplied directly from service voltages above the 15 kv class and nominally rated at 22 kv and 33 kv. This fact resulted in the development of a compressed air furnace breaker to replace oil circuit breakers which had in the past been used when such cases arose. Figure 7 shows an installation view of a compressed air circuit breaker developed specifically for arc furnace duty. This breaker was designed with the intention of being applied in conjunction with a "back-up" or circuit protective breaker. The function of the "back-up" breaker is to protect against primary circuit faults while the function of the compressed air breaker is to perform the highly repetitive operation required in the working of a furnace, and thus to interrupt only normal and overload currents. With such application intent in mind, this breaker had no interrupting capacity in the sense of such a rating being applied to power circuit breakers. Because of the economics prevailing under certain conditions, it was recently deemed advisable to build a compressed air breaker that would have an interrupting capacity of about 500,000 kva. When such a breaker is applied on a circuit having an interrupting capacity not exceeding this value, it may then be used for both the combination repetitive duty and fault interruption duty. There are two designs of this breaker currently being applied: one for service on 15-kv circuits and the other for service on 34.5-kv circuits. These breakers are pneumatically operated and the arc interruption is obtained through use of an air-blast. Surge suppressing equipment is provided with this form of breaker to limit the overvoltages which can and do occur during arc furnace switching.

FURNACE REGULATORS

Arc furnace electrode positioning regulators of both the rotating type and the balanced beam contactor type are continuing to serve in the regulation of power input to steelmaking electric arc furnaces. All newer steelmaking furnaces are making use of the rotating type regulator because of the maintenance advantages which it offers. Figure 8 shows a typical rotating type furnace regulator used with large size electric furnaces. Arrangements of the three machines—one for each electrode—other than that shown here presently are being used for the very largest sizes of regulators. The main criteria in the choosing of an arrangement are generally those having to do with ease of maintenance and best usage of floor space or head space in each particular case. Improvements have been made in circuitry and in the design of the individual rotating units themselves, and one notable improvement has been the development of a recalibrating device for regulators to insure against operation at conditions other than those which correspond to optimum for a given tap voltage.

In conclusion, it may be stated that as the use of the arc furnace has grown in industry, and as the size of the furnaces used became larger, the electrical equipment required has always been readily made available. Just as the past has seen continual improvement made in electrical equipment, so shall the future see such improvements.

Figure 8 — This modern rotating type regulator is used for positioning electrodes of a three-phase furnace.

DISCUSSION

PRESENTED BY

DALE R. COCHRAN, Application Engineer, Steel Mill Engineering, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

CHARLES W. VOKAC, Manager, Hydro-Arc Furnace Dept., Whiting Corp., Harvey, Ill.

Dale R. Cochran: In addition to the equipment described by Mr. Browning, I believe that the matter of capacitors for power factor correction is also quite important. A poor power factor situation may exist in small mills where there is little or no synchronous machinery.

A good method of solving power factor problems such as this is to use shunt capacitors connected to the primary of the furnace transformer. Thus, the power factor can be corrected to 90 or 95 per cent very easily and in many cases will pay for themselves in a very short time.

Capacitors connected to the primary of the furnace transformer must be switched on or off when the furnace transformer is switched. There are two methods of achieving this. The most desirable method is to use a separate circuit breaker similar to the furnace breaker and arrange both breakers to operate simultaneously. However, in some cases, economics rule out the use of separate breaker for switching capacitors. If this is the case, arrangements can be made to utilize the furnace breaker for switching both the furnace transformer and capacitors simultaneously which means that the capacitors are permanently connected to the transformer primary. When this is done, it is necessary to use an arrangement which prevents operation of the furnace transformer tap-changer for a period of time after opening the furnace breaker to allow sufficient time for the capacitors to discharge through the transformer primary. If a time delay is not used, it is possible for tap changer damage to result due to interruption of the capacitor current discharging through the transformer winding. However, an intentional time delay may not be too objectionable, because a five second delay will be sufficient in most cases. This method does permit power factor correction at minimum cost.

One other point not mentioned by Mr. Browning is the use of pyranol type furnace transformers. In some cases, particularly for laboratory arc furnaces, a pyranol transformer offers an opportunity to save in building costs by eliminating the necessity for a furnace transformer vault. It is necessary to have a clean location since no vault is required. However, a pyranol transformer is limited to small sizes and to locations similar to a laboratory.

Charles W. Vokac: I should like to make a comment on this problem of proper circuit breaker protection for arc furnaces. I want to be sure that people designing this equipment will keep in mind that we are continually striving for simplicity. Complicated machines for a simple job can always be designed, but a simple, relatively maintenance-free machine for a complex job is what we want.

We recognize the complexity of the three principal functions that the breaker must fulfill, the first and perhaps the most important one being the short-circuit protection of the line, the second, the interruption of arc-current loads, and the third, the interruption of the much smaller exciting current load of the transformer. We understand also that the three functions, from a design standpoint, are not exactly related and each must be handled more or less individually. The duty cycle of these functions only adds to the complexity of the problem.

We recognize also that the breaker that will give the proper short-circuit protection must be extremely fast in operation and consequently the mechanical moving parts must be low in inertia, light in weight, yet strong and sturdy to withstand the repeated operations without beating itself to pieces.

We realize that the magnetizing forces of the light, medium, and heavy arc currents drawn within the breaker during interruption also require almost diametrically opposite solutions.

It would seem that the simplest solution would separate these apparent diametrically opposite requirements into two separate units but, unless this reduces the complexity of each unit and the cost of each unit too, using two equally complex, equally costly units is not the solution that will resolve itself into less cost per ton of metal produced, the desired end result. The best solution is the simplest one, and we should strive toward that end.

Another thing I wanted to mention was the question of pyronol, askarel, inerteen, or other nonflammable insulating fluids for arc-furnace transformer application. This is a subject that would require quite a dissertation in itself, but I want to mention only one part of it here. Some feel that the use of this fluid would obviate the necessity of a special vault for the transformer and other equipment. It is inconceivable, in any arc-furnace applications, be they foundries, mills or smelting plants, that anyone would want this equipment put out into the same atmosphere that the furnace may be in. This equipment should be in a clean vault, ventilated with filtered air and under lock and key for safety. Besides, the difference in cost of this type and the standard type of transformer, presently, is sufficient to pay for the vault.

Another point I wish to mention related to keeping things simple and relatively maintenance free, is the work our company did, for the past year or two, with the cooperation of the University of Illinois, Kensington Steel Company, and others, on a new type of arc-furnace regulator. This regulator energizes the electrode motors directly from the furnace bus without any special generators. The electrode motors run in one direction only and do not reverse. This point alone is considered by many an interesting contribution toward the solution of a much discussed problem. Preliminary work on this new regulator had been completed in our research laboratory and the first stage of an exhaustive research program had been completed at the University of Illinois. Presently, one such regulator is in operation on a furnace at the Kensington Steel Company for observation in production and collection of operating data.

By W. S. DEBENHAM, Research Associate, Research and Development, United States Steel Corp., Pittsburgh, Pa.

BRICKLAYING AS A FACTOR IN THE PERFORMANCE OF BLAST FURNACE LININGS

. . . . perhaps the most important element in a furnace lining is the workmanship which goes into placing it . . . .

▲ THE principal factors governing the life of refractories in any type of application are:

1. Correctness of the type of refractory selected.
2. Uniformity of quality of the refractory selected.
3. Quality of the job of installation.
4. Furnace design.
5. Severity and uniformity of operating conditions.

For maximum effectiveness of a program aimed at improved refractory performance, it is necessary to know the relative importance of these factors, including the effect of their variations on each other and on lining life. This is a large order, and probably none of these factors would be more difficult to isolate and appraise from the standpoint of effect on lining life than the one assigned for this discussion—quality of the job of installation. Considering the frustration that generally results from efforts to resolve bricklaying quality into dollar and cents costs, one might wonder at the amount of attention that has been focused on this phase of refractory application. The more cynical among us might attribute it to a general unwillingness to face reality and admit that bricklaying has been made the scapegoat for a host of operating evils which constitute the true cause of blast furnace lining difficulties. A more charitable, and indeed, a more truthful explanation would be that this interest reflects an earnest desire to determine the real significance of those factors listed above. However strongly one might feel regarding the overriding influence of operating conditions on lining life, his arguments remain fairly weak until he can demonstrate that nothing further can be done to improve the quality of the job of installation. It is doubted that anyone would attempt such a demonstration today. If he were so bold, it is certain that he would not be very convincing to an operator who had just relined a furnace for the third time in the past four years.

Just what does constitute a good job of bricklaying? In the strict sense, good bricklaying means adherence to all the recognized rules governing the mechanics of the job, such as tight joints, accurate courses, proper closures, broken bonds, etc. Everyone concerned professes belief in these things, but considerable controversy arises when a more precise definition of these terms is sought. Differences of opinion probably have existed as long as there have been blast furnaces, and men to operate them, men to supply the brick, and men to lay them. That even operators have not been able to agree was indicated as far back as 1917, when J. E. Johnson, Jr., stated in his book "Blast Furnace Construction in America":

"Many of the difficulties with linings have been attributed by some furnace men to bad bricklaying, and particularly to wide joints. Some go so far as to insist that all unevenness must be removed from the brick by chipping each individual brick where any appreciable amount of warpage exists, producing what is known as a case knife job. This means that every joint shall be laid so close that it is impossible to get a point of a table knife into it.

"Thick joints are undoubtedly very bad, but I have never seen any results produced by such extreme precautions which seem to me to justify the very greatly increased expense in laying the lining by this method."

Despite Mr. Johnson, that table knife still comes out of hiding with considerable frequency, although we will grant him that on some occasions it would be more appropriate to use the handle than the blade.

However, there is more to a good bricklaying job than the skill and conscientiousness of the bricklayer. It is still true that a silk purse cannot be made of a sow's ear; and a good bricklaying job cannot be made with warped or off-size brick or with a selection of brick shapes that unnecessarily complicate the job. Also, from the standpoint of overall durability, good bricklaying must encompass proper design and construction methods. The most correctly laid walls may go for naught if they are improperly or inadequately

supported, or if laid to conform to distorted or out-of-plumb steelwork.

In its broader sense, then, it is evident that good bricklaying includes, or is influenced by, other factors governing lining life. And there is as much divergence of opinion on these matters as there is on the question of joint thickness. It would seem that the only possibility for alleviating this situation would be the establishment of some standards whereby all phases of the job could be evaluated. This formidable task was recently undertaken by a subcommittee in our company. The following discussions are concerned with some of the specific questions considered by this group, and are offered more as a matter of interest, and possibly to stimulate new thought on accepted practices, than as a set of recommended standards.

BRICK QUALITY

We have heard much concerning the excellence of the work of the old time bricklayers. While we are in no position to deny such claims, we doubt that the bricklayer of thirty years ago would know what to do with the hard-burned brick of today. The relatively soft brick of that era were cut with ease and readily rubbed to a smooth cut with a carborundum stone. In fact, similar soft-burned brick are still furnished for applications requiring a great deal of cutting, such as pipe linings. Current blast furnace brick make saw cuts almost mandatory, and also emphasize the importance of accurate sizing. While there is no question that size uniformity of blast furnace brick has greatly improved, we will never escape the necessity for compromise between what is desired and what can practically be produced. The practical limit of uniformity might be defined as that which can be produced in adequate volume without incurring extra charges. The experience of recent years would indicate that this limit is governed more by availability than by cost, as there has been a general willingness to pay extra for brick of superior properties. However, it has also been indicated even more recently that the practical limit of size uniformity is not fixed, but, with a little interest on the part of the consumer, can be improved substantially. Table I shows a comparison between the dimensional uniformity of two linings, one of which caused complaints, while the other was considered satisfactory. The latter may be considered representative of today's practical limit of uniformity. If it seems that such a lining still would not permit the attainment of the job of installation desired, it would be well to bear in mind that the first limitation to the ideal job is the materials furnished the bricklayers.

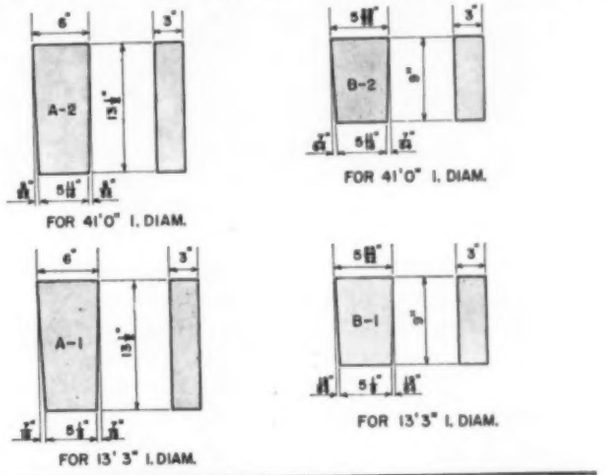
TABLE I

Comparison of Size Variance of Two Linings

	Length		Thickness		Warpage Avg
	Range	Avg	Range	Avg	
9-In. straights					
Poor lining	0.40	9.03	0.18	2.97	0.03
Good lining	0.14	8.95	0.16	2.98	0.01
9-In. keys					
Poor lining	0.40	9.11	0.26	2.96	0.03
Good lining	0.18	8.93	0.14	2.99	0.01
13½-In. straights					
Poor lining	0.50	13.62	0.12	2.93	0.05
Good lining	0.24	13.53	0.16	3.01	0.02
13½-In. keys					
Poor lining	0.40	13.59	0.22	2.95	0.05
Good lining	0.30	13.52	0.14	3.01	0.02

BRICK SHAPES

Another factor residing in the materials furnished the bricklayer is the shape of the brick itself. While this is a matter that has been given considerable attention,



DIAMETER INSIDE BRICKWORK	NUMBER REQUIRED PER RING			DIAMETER INSIDE BRICKWORK	NUMBER REQUIRED PER RING		
	A-1 OR B-1	A-2 OR B-2	TOTAL		A-1 OR B-1	A-2 OR B-2	TOTAL
13'-3"	98		98	27'-0"	49	135	184
13'-6"	96	3	99	27'-6"	47	140	187
13'-9"	95	6	101	28'-0"	45	145	190
14'-0"	95	8	103	28'-6"	44	150	194
14'-6"	93	13	106	29'-0"	42	155	197
15'-0"	91	18	109	29'-6"	40	160	200
15'-6"	89	23	112	30'-0"	38	165	203
16'-0"	87	28	115	30'-6"	37	169	206
16'-6"	85	33	118	31'-0"	35	174	209
17'-0"	84	37	121	31'-6"	33	179	212
17'-6"	82	42	124	32'-0"	32	184	216
18'-0"	80	48	128	32'-6"	30	189	219
18'-6"	79	52	131	33'-0"	28	194	222
19'-0"	77	57	134	33'-6"	26	199	225
19'-6"	75	62	137	34'-0"	24	204	228
20'-0"	73	67	140	34'-6"	23	208	231
20'-6"	71	72	143	35'-0"	21	213	234
21'-0"	70	76	146	35'-6"	19	219	238
21'-6"	68	82	150	36'-0"	18	223	241
22'-0"	66	87	153	36'-6"	16	228	244
22'-6"	65	91	156	37'-0"	14	233	247
23'-0"	63	96	159	37'-6"	12	238	250
23'-6"	61	101	162	38'-0"	10	243	253
24'-0"	59	106	165	38'-6"	9	247	256
24'-6"	57	111	168	39'-0"	7	253	260
25'-0"	56	116	172	39'-6"	5	258	263
25'-6"	54	121	175	40'-0"	4	262	266
26'-0"	52	126	178	40'-6"	2	267	269
26'-6"	51	130	181	41'-0"		272	272

SPECIAL 13½" AND 9" BLAST FURNACE KEY COMBINATIONS

DRAWN BY H.A.S.	CHK'D BY	APPROVED BY	UNITED STATES STEEL CORPORATION RESEARCH AND DEVELOPMENT PITTSBURGH, PA.	FIGURE NO.
DRAWING NO		PROJECT No		
		DATE 10-1-53		

Figure 1 — These special 13½ and 9-in. blast furnace keys will make it easier to lay blast furnace linings.

it undoubtedly will come as a surprise to many that the present standard sizes are better adapted to the 10 to 15-ft furnace of 50 years ago than to the 28-ft giants of today. Thus the standard 9-in. No. 1 key turns a 13-ft circle and the standard 13½-in. No. 1 key turns an 11-ft

3-in. circle. Since these keys have different tapers and different small end dimensions, their use with the necessary large number of straights makes it difficult to maintain good brick bond without the use of an excessive number of special, extra-width keys. This problem of proper shapes for conical structures was considered as early as 1893 when a patent was granted to C. H. Foote covering a series of segmental shaped brick. Later, in 1929, J. C. Morehead received a patent for a very similar construction. In both methods, straight brick are eliminated or greatly reduced. This would appear to be a far more desirable construction, and certainly warrants consideration for present day furnaces. The improvement obtainable may well be analogous to that which resulted from the adoption of the special 1 X wedge for open hearth roofs, in place of the combination of Standard No. 1 wedges and straights. Roofs are now often built entirely of wedge shapes, with improved structural stability. Figure 1 shows key shapes that might be used for blast furnace linings. It will be noted that all shapes have the same small end width. One shape in both the 9 and 13½-in. lengths turns a 41-ft circle, the largest diameter encountered in our largest furnaces. Another pair of shapes turns a 13-ft-3-in. circle, corresponding to the smallest diameter in present furnaces. By proper combination of these shapes as shown in the table, the entire lining can be constructed of key brick, with less difficulty in breaking bonds.

PROPER ALIGNMENT OF THE LINING

The achievement of optimum lining life is believed to be so dependent on proper alignment of the lining, furnace shell, and charging equipment that some mention of the procedures involved is warranted.

It is desirable that the inner surface of the lining both above and below the mantle shall be concentric with a centerline which is plumb, regardless of any tilt in the furnace shell. If, in the case of a tilting furnace, this should mean that after all means of correction have been exhausted, such as leveling and shifting the lip ring or using steam in the columns or jacks to raise the furnace on the low side, the lining must still necessarily be thicker on one side than the other, so be it. Such a lining is undesirable, but preferable to one whose inner surface is concentric with a tilting center line.

It is obvious that to properly line a furnace to a plumb line, a trampole or center pole is necessary. This trampole should be checked at the start of each turn and each inner course of brick should be trammed as it is being laid. In some cases, methods of scaffold construction or brick handling prevent the use of a center or trampole. In that event, an alternate procedure involving the use of four lines dropped from the top of the furnace at the quarter points, and set by a plumb line, has been found satisfactory, although it requires a quadrant-type template to check all points in the circle.

PACKING BETWEEN STACK LINING AND SHELL

Probably no item of blast furnace construction has been handled in a greater variety of ways, or is of potentially more importance, than the filling of the space between the stack brickwork and the shell. Materials that have been used include blast furnace slag, wet and dry fireclay, diatomaceous insulating granules, clay bonded expanded vermiculite, loam, cement bonded clay and refractory concrete. In some cases all such materials are dispensed with and the brick laid right to the shell. Where spacing is used, it has also been a common practice to use slip joints every few courses, consisting of a ring of brick pulled out to contact the shell. Reasons for these slip joints have been stated to be either the confinement of any settling of the filling to certain sectors, or the prevention of the loss of all filling in case of a shell rupture. Actually unless extreme care is taken, about all such joints accomplish is the creation of a series of annular voids beneath each slip joint which often contribute nicely to the channelling of gases and the extension of hot spots when they occur.

The basic reason for any packing space is fear of brickwork expansion causing cracking of the shell. Such fears may be justified where extremely old shells are involved, particularly on furnaces subjected to sudden climatic changes, but otherwise experience has shown that no difficulties have resulted from laying brick against the shell or even pouring the packing space with refractory concrete. We now consider it so important that a solid backing for the brickwork be provided to prevent openings in the brickwork, and the by-passing of gases, as has too often been the case when dry clay fills have simply been poured behind the lining, that we have adopted the practice of either laying the brick tight against the shell, or solidly packing a 2 to 4-in. space with dampened clay. In the latter case, the packing should be tamped at intervals not exceeding 3-ft in height, preferably with a pneumatic rammer. Greater experience with concrete packing will probably result in an extension of this practice. One such installation on an old, previously-cracked shell, resulted in further cracking of the shell, but the furnace lining remained very tight.

BOSH AND STACK COOLER ARCHES

It is probable that no greater differences can be found in the procedures used in relining blast furnaces than in those involved in the installation of bosh and stack coolers. Many plants employ intricate and complicated cooler arch shapes, with little or no standardization, while other plants simply cut standard wall brick over all coolers, in some cases not even forming a true self-supporting arch. The nature of the special shapes, and the lack of standardization which would permit volume production, necessitates that these shapes be hand made, with a resultant decided lowering of the quality as compared with that of the balance of the lining. It would appear that these practices warrant study that would lead either to the establishment of standard special shapes that could be machine-made, or to recommendation for their elimination. The good experience that has been obtained without special shapes, and the savings in manhours, certainly indicate that serious consideration of this practice is justified.

BRICKLAYING

It is not intended that this paper cover all the details involved in good bricklaying practice. Excellent manuals on this subject may be found elsewhere. However, the following practices pertaining primarily to blast furnace linings are believed to be worthy of mention here. If these still seem fundamental, it would be well to bear in mind that the chief reason for listing them is that they are often not observed:

1. Mortar should not be spread over an area which exceeds 5 ft or 10 brick widths in length, and the full length of the brick in width at one time. All bed and cross joints should be completely filled with mortar.
2. All excess mortar from each row or ring of brick should be removed before the succeeding ring is laid.
3. Hearth block should be laid with the brand side of the block in the same direction, as any curvature in the block is usually related to the direction of pressing. The top course of bottom block should be laid at approximately right angles to the tapping hole.
4. If the difference in height, as laid, between a given bottom block and any other in the same course is greater than $\frac{1}{16}$ in., the block should be ground.
5. Periodically, bottom block should be plumbed and a straight edge laid across the 18 x 9 in. face to make sure certain rows are straight.
6. Cuts or closures of bottom block rows should be made with cut bottom block and not 9-in. series brick. Plastic, carbonaceous fills have been used satisfactorily for this purpose.
7. All bottom blocks should be laid in mortar of heavy cream consistency which is thin enough to flow off the trowel. Brush joints may also be used.
8. The bottom should be swept clean of brick spalls and foreign matter before each course is laid.
9. Each block as laid should be rubbed into place and tapped on each exposed face with a wooden or rawhide mallet until solidly in place.
10. Wall brick should be laid with pushed joints and each brick tapped into place with a wooden or rawhide mallet.
11. In laying brick to a trampole, the inner course should be laid slightly away from the trampole and then driven to it. Driving brick away from the trampole toward the furnace shell loosens the course, causing open joints.
12. All joints in the vertical plane should be broken at least one inch, using extra width key brick if necessary. This also applies to vertical joints in a horizontal plane.
13. Only one closure should be permitted in each row or ring of brick around the furnace periphery. Closure brick should be smooth cut and not less than 3 in. in width. Closures should be rotated 30 degrees, at each scaffold and staggered approximately 2 ft in each succeeding course to prevent poor brick bond. Closures should be completely eliminated in the region 30 degrees on either side of tapping hole.
14. No stretcher courses should be permitted in walls, all brick being laid as headers.
15. The reversing of keys in walls due to shortages of straights should not be tolerated.

It is obvious that all the innumerable details that must be observed to obtain a satisfactory job of installation require constant close and vertical supervision. It should be equally obvious that we should not expect that type of supervision from the men who also has been given the responsibility for completing the job by next Tuesday, or else. But this is too often the case. The job of supervision should be divorced from the job of construction, and should carry sufficient authority to stop the work, if need be, to assure that the standards of quality are being maintained. Such an arrangement will inevitably lead to misunderstanding and ill-feeling unless there has been a prior agreement among all concerned as to what these standards of quality are. It is hoped that the foregoing discussion may prove of some benefit in suggesting the nature of such standards by revealing some of the problems and limitations involved in obtaining a suitable job of installation.

DISCUSSION

PRESENTED BY

J. M. STAPLETON, Assistant to Vice President, Blast Furnaces, United States Steel Corp., Pittsburgh, Pa.

J. M. Stapleton: Mr. Debenham's paper lends emphasis to the general recognition of the positive effect bricklaying practices have on performance of blast-furnace linings. All blast-furnace plant organizations charged with the responsibility of furnace-lining installations have for some years observed the policy of meeting very tight completion schedules. Many times, I am sure, even though expediting furnace relinings or rebuildings, all known precautions were taken to insure quality bricklaying workmanship. However, a historical review of linings over the past 15 years has pointed up some instances where deviation from established bricklaying standards no doubt contributed to poor lining performance.

Mr. Debenham and his colleagues in recent years have developed standard bricklaying practices for U. S. Steel Corp. plants, and are still hard at work on their further improvement and refinement. As he has pointed out in his paper, some of these principles and protective measures, while well known to those immediately concerned with furnace-lining work, probably are overlooked at times, or deviated from in the belief that no ill effects would result to the linings, and some gain would be realized in the time the furnace is out of operation.

I believe we all recognize there is no substitute for good workmanship when it comes to laying up furnace linings. And when you have a set of practice standards developed by blast-furnace operators, technicians, masons, ceramic engineers and suppliers; likewise, there is no substitute for strict compliance if we are to obtain expected lining life and performance.

By F. R. PULLEN, Fuel Engineer, Bethlehem Steel Co., Johnstown, Pa.

Fuel Selection for Soaking Pits

. . . . high air preheat stepped up the performance of this soaking pit installation

. . . .

▲ THE recent modernization program at the Johnstown plant of the Bethlehem Steel Co. included a 46-in. high lift blooming mill. The site of the new mill lay between the existing 34-in. slabbing mill (which was to be abandoned) and the 40-in. blooming mill. The soaking pits which served these two units were obsolete regenerative soaking pits and had insufficient capacity to supply the new mill. In addition, the locations of these pits were such that an entire new pit installation was necessary.

The space available for the soaking pit installation was limited. The area was hemmed in by existing structures which could neither be moved nor abandoned, at least until a portion of the installation was completed. Since the 34-in. slabbing mill was to be abandoned at the completion of the program, the new pits could occupy part of the site occupied by the 34-in. mill pits, provided temporary measures could be taken to feed steel to the 34-in. mill from the first of the new pits to be placed in operation.

The 46-in. mill replaced both of the mills at Franklin and also the 48-in. blooming mill in the lower works. The capacity of the new mill is greater than the combined capacity of the three mills, as a sizeable increase in production had to be accomplished. The former installations were served by a total of 51 holes of soaking pits, all of which were regenerative furnaces. The combination of the increased production rate, the varied grades of steel, and type of products rolled on this single breakdown mill made it necessary to install the maximum square feet of available hearth area under the one roof.

The size of ingots in use, as well as the number in each heat were tabulated, and ingot charging patterns were laid out for various sizes and shapes of soaking pits. A rectangular pit of approximately 7 to 8 ft in width and between 20 to 22 ft in length was tentatively selected as the one producing the maximum useable hearth area.

The manner of firing and type of heat recovery equipment was next studied. Again due to the lack of space, it quickly became apparent that a one-way-fired recuperative soaking pit was our only choice. These details were all worked out in the plant by the various plant engineering and operating departments. At this point all of the data was furnished to various builders of soaking pits to prepare designs and quotations for soaking pits to heat 180,000 ingot tons per month with an average track time of 3 hours and with a 5 per cent cold steel charge. They were advised of the approximate area available and instructed to get the maximum hearth area in that space. The pits finally selected were each 7 ft 6 in. wide x 20 ft 6 in. long x 11 ft 6 in. deep. These were to be one-way-top-fired recuperative soaking pits, and were to be installed in six batteries of five holes each, or a total installation of 30 holes.

The fuel selected for these pits was the subject of almost as much study as the pits themselves. As was mentioned previously, the old pits were regenerative pits and were fired with 135 Btu fuel in two cases and 180 to 200 Btu fuel in the third case. Each of these fuels were mixed blast furnace and coke oven gas. The new pits were estimated to require a maximum fuel input of 430,000,000 Btu per hour. This was a sizeable increase in the amount of fuel consumed in the existing 34 and 40-in. mill pits due to the increased tonnage to be handled. Thus it became necessary to check the plant fuel balances carefully to determine the availability of both blast furnace gas and coke oven gas. These balances were revised to include the presently authorized plant expansion as well as future proposed construction. Previous experience with low Btu fuel on regenerative pits established the desire to use the same fuel on the new pits, if such was available and could be utilized with satisfactory results.

The source of the blast furnace gas is the five blast furnaces at Franklin Works. One of these furnaces normally produces ferro-manganese. All of the gas is cleaned in conventional tower washers and disintegrators to an average cleanliness of 0.0085 grains per cubic foot. It is used for heating stoves, boilers for steam generation, soaking pit furnaces and one battery of coke ovens.

The source of the coke oven gas is three batteries, consisting of a total of 228 ovens, located at the Franklin Coke Works. These batteries supply clean coke oven gas of approximately 530 Btu per cubic foot to soaking pits, mill reheating furnaces, the open hearth furnaces, in addition to underfiring two of the batteries.

The fuel balances revealed that sufficient quantities of either fuel were available. In fact, the balances indicated that the fuel should be essentially blast furnace gas. In the event that it were not used at the soaking pits, it would be bled or wasted. While blast furnace gas is not considered to be a premium fuel, it is a good fuel when properly used. The addition of a large block of base load gas consumers in the 30-in. pit furnaces was desirable. This brought our base load consumers

up to approximately 35 per cent of the total gas produced. Even with two furnaces off, or on reduced operation, for various reasons we were still able to meet full pit furnace demand. Since the boilers were taking the remainder of the gas above base load, and were equipped with alternate fuels, the decision was made to provide only one fuel which would be essentially blast furnace gas.

It is our opinion that coke oven gas, a premium by-product fuel is too valuable to utilize as a primary fuel in soaking pit operations, or under boilers as a normal operation. In distinction from blast furnace gas it lends itself to plant-wide distribution pipe lines. It is also a suitable fuel for use in practically all mill applications and has come into its own as an open hearth fuel in recent years. Therefore, it would have been with considerable reluctance that coke oven gas would have been applied as the primary fuel on these pit furnaces.

Purchased fuels were not considered for two principal reasons, namely: (1) cost, and (2) supply. Natural gas was not available, and even if it had been an alternate fuel would have been necessary. The cost of fuel oil was prohibitive.

Having arrived at the conclusion to use blast furnace gas as the basic fuel for the soaking pits, the application of this fuel became the next problem. It was mentioned previously that one of the blast furnaces produces ferro-manganese. The gas from this furnace is approximately 25 per cent richer than from a basic iron furnace. This presented a problem, however, since under the normal fluctuations of blast furnace operation, and because of the physical arrangement of the gas piping, it was possible under certain combinations of circumstances to get practically all ferro-manganese gas at the pits. To prevent this by changing piping at the gas plant would have been prohibitive in cost. To attempt to operate with such variation in fuel, quality was out of the question. In order to deliver a constant Btu valve to the soaking pits, a calorimeter-controlled mixing station was installed at the pits to mix the proper quantity of coke oven gas with the blast furnace gas so as to produce a mixed gas of 135 Btu. This is approximately 10 Btu over that produced on the ferro-manganese furnace.

Having arrived at the decision to use 135 Btu fuel, its application to the pit furnaces and their performance was next studied. One-way-fired recuperative soaking pits utilizing low Btu fuel have been in operation for a number of years. There was much to be desired in their operation, however. The use of hot-air fans added much to the maintenance cost and the limit on the amount of air preheat affected their operation.

The use of much higher preheat air temperature should increase the heating rate of the pit considerably by producing a higher flame temperature. A system of recuperation in which hot air fans were eliminated on one-way fired pits had been built and placed in operation approximately one year prior to this study.

The operating results of this particular installation were reported by E. H. Cauger and J. C. Stamm, Jr. at the A.I.S.E. Annual Convention in Chicago on October 3, 1951. This paper is found on page 836 of the 1952 Yearly Proceedings of the Association of Iron and Steel Engineers. By employing this system of recuperation and increasing its heat transfer capacity, it was felt that an air preheat temperature of 1400 F could be attained. This then was set as our goal. In order to accomplish this, the amount of ceramic recuperation (first pass) was increased approximately one third. The metallic recuperator (second pass) was also increased in size. The approximate ratio of 2.1 volumes of flue products per volume of air on low Btu fuel as against the ratio of 1.15 volumes of flue products per volume of air on coke oven gas assists materially in the increase of air preheat temperature. High air preheat when firing with low Btu fuel is also desirable from an economy point of view. Due to the large volume of flue gases handled, a small decrease in final flue gas temperature produces a sizeable annual saving in the fuel bill.

It is our opinion that low Btu fuels are at least equal to and possibly superior to the richer fuels for soaking pit operation. We feel that this is especially true when one-way fired pits are used. The lower flame temperature is, in our opinion less likely to overheat or burn steel. This is particularly true on some of the "tender" steels. The quanity of defective steel produced in the pits using low Btu fuel on our old pits which were all regenerative and were not equipped with any controls or instrumentation, was small. The same type of defect has been eliminated, or virtually so, in the new pits. In addition the higher flue gas volume, with higher circulating rates on low firing rates, tends to produce a somewhat faster soaking out and a more uniformly heated pit. This was not a problem in regenerative pits, where circulation was good at all firing rates.

The pit furnaces have been in operation for approximately two years. There have been and still are some problems to be solved. Contrary to expectations, the blast furnace gas has proved to be highly corrosive at the temperatures at which the metallic recuperators operate. Various types of stainless sheet steel were used to fabricate the tubes. While the higher chrome steels seem to be superior, even these left much to be desired. Tubes of a high-chrome cast alloy are now in service and appear to be an improvement over the sheet-steel tubes.

Some difficulty was experienced with the burners. This was brought about by leakage in the burner connections allowing gas to escape into the hot air. The air was at a temperature sufficient to cause ignition, resulting in the destruction of burner internal parts.

We believe the performance of these particular pit furnaces has not reached its ultimate since they have had to operate under conditions different from those included in the specifications. Track time has been nearer 4 hours than the 3 hours specified. Cold steel has averaged nearly 10 per cent instead of the 5 per cent estimated originally. These conditions are abnormal, due to the fact that pit furnaces and the mills began operation prior to the completion of the modernization of the open hearth furnaces, open hearth strippers and ingot-track layouts. As a result, steel is generally colder than desirable when charged; and since mill capacity, at present, exceeds steel producing capacity, cold steel must be charged to keep the mill at full operation.

Analysis of a number of heats, however, indicate that steel with nearly normal track time is generally

ready to roll in track time (interval between start pour and start charge) plus 30 minutes. Mill schedules may make the actual drawing time longer than this. However, it can be said that the pit furnace has done its job when the steel is ready to roll.

From a quality point of view, the installation has been extremely successful. Despite the long holding times encountered, due to mill schedule, the scale loss is normal and is improved over that previously experienced with the old pits. The low Btu fuel and resultant lower flame temperature reduces the ingot washing potential. It can be safely said that few ingots washed in these pits have been washed due to the failure of the temperature sensing element. The quality of steel as reflected by the inspection of the final product has been excellent. Practically all reconditioning is to remove rolling defects or original steel defects. There has been no evidence of "burned steel," or other defects chargeable to the soaking pits.

After operation of these furnaces for two years, it is our opinion that our original decision to use low Btu fuel was most fortunate from a quality standpoint. The use of high air preheat to step up the performance of the installation has resulted in a soaking pit installation which is essentially comparable to properly designed regenerative pit furnaces operating on similar fuels.

DISCUSSION

PRESENTED BY

E. T. W. BAILEY, Chief Combustion Engineer, The Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada.

F. R. PULLEN, Fuel Engineer, Bethlehem Steel Co., Johnstown, Pa.

J. LEDLIE MILLER, Assistant Chief Construction Engineer, Republic Steel Corp., Cleveland, Ohio.

H. H. DINNEEN, Chief Engineer, Rust Furnace Co., Pittsburgh, Pa.

A. C. GRAY, Superintendent, Bloom, Billet and Conditioning, The Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada.

J. B. RUBRIGHT, Field Fuel Engineer, Republic Steel Corp., Buffalo, N. Y.

E. T. W. Bailey: Does Mr. Pullen have any idea what element or elements in the waste products from burning blast furnace gas attack the metallic recuperator?

F. R. Pullen: We are not certain what elements in the flue gas are responsible for the attack on the metal tubes. We can only assume the attacking agent or agents to be in the blast furnace gas. This type of recuperator has been reported to have been in use on furnaces firing fuel oil and coke oven gas for some time, and with marked success. Since none of these installations were in plants of the Bethlehem Steel Company until recently, we are not prepared to make any definite statements as to tube life, etc. This particular installation was one of the first to operate on flue gas produced by burning mixed blast furnace and coke oven gas.

Analysis of the deposits on the tubes indicate probable formation of low melting point alkali enamels which condense on the cold tube surface in droplet form and collect to form a scab. Corrosion takes place beneath this scab. Analysis of the deposit on the tubes revealed that most of the well known elements were present in some degree, and probably represents the accumulation of trace and minute quantities of all of these elements in the ores and other raw materials charged to the blast furnace.

J. Ledlie Miller: You said you roll 180,000 tons. Is that finished tons?

F. R. Pullen: Figures are ingot tons.

J. Ledlie Miller: How much coverage do you have for that 180,000 tons, and how many holes are there?

F. R. Pullen: Thirty holes or approximately eight hours coverage, ahead of the mill.

J. Ledlie Miller: You have about eight hours? Can you do that with 135 Btu gas?

F. R. Pullen: Yes.

J. Ledlie Miller: On the fuel-air control, is the air retained constant or is it a fuel air ratio application?

F. R. Pullen: Fuel-air ratio control is maintained on each pit.

H. H. Dinneen: I would like to ask how the author arrived at the 135 Btu per cu ft figure. Obviously, he could not go much lower, but a higher value might have been indicated.

F. R. Pullen: The Btu of the mixed gas was kept to a minimum so as to utilize a minimum of coke oven gas. We prefer to use coke oven gas to replace high cost fuel oil on steel producing and reheating furnaces. Furthermore, our experience with low Btu fuel on regenerative pits led to the desire to utilize the same fuel on our new recuperative pits. If possible, we could reduce the Btu to a still lower level. Mixing station control and the utilization of ferro-manganese gas under certain conditions, make the range of 130 to 140 Btu desirable and that level can be maintained at all times.

A. C. Gray: How many tons do you get per 1,000 square feet hearth area per hour? What is the Btu figure per ton?

F. R. Pullen: The monthly average ingot tons heated per hour per 1000 square feet of heating surface is 56.3. The record daily figure is 67.5 tons per hour per 1000 square feet of heating surface.

The average fuel consumption for the first nine months of 1953 was 880,000 Btu per ton. This has been gradually decreasing as tonnage increased, and steel movement improved to a low of 730,000 Btu per ton in October.

Both tonnage rate and fuel consumption are adversly affected by steel scheduling problems as was pointed out in the paper, since it is necessary to feed steel for three semi-finishing mills simultaneously through the same blooming mill.

J. B. Rubright: Did you give any consideration to pre-heating the blast furnace gas?

F. R. Pullen: Preheating of blast furnace gas was discussed in some of our early conferences prior to development of the final specifications for these soaking pits. Although the practice is carried on extensively in Europe it was not felt to be either desirable, or necessary, in this case. In view of the corrosion problem which developed with the blast furnace gas we seem to have made a fortunate decision to say the least.

USE OF OXYACETYLENE IN ROLLING MILLS

By R. L. DEILY
Steel Mill Representative
Air Reduction Co.
New York, N. Y.

. . . . more and more uses of oxyacetylene are being found to be economical in steel plant operations . . . .

▲ THE great increase in steel capacity and present high rate of operations have forced the production use of oxyacetylene cutting equipment in rolling mills to be much expanded. The maturing of the hand torch from routine maintenance to standard production applications in engineered cutting machines has added a new facet to the roll mill designer's art.

Use of machine scarfing in rolling mills is an accepted procedure, and it is doubtful that any major revision or new construction of steel mill plants will be contemplated without serious consideration of this process. Certainly, if the scarfing machine installation is not made at the time of construction or revision, ample room in the mill set-up will be provided for future machine scarfing.

Of possibly even greater importance to the rolling mill designer and operator is the adaptation of the cutting torch to machines in order to make consistent cuts on rolled stock at production speeds. In addition to providing the rolling mill operator with a rugged production tool of usual mill machinery dependability, these hot cut-off machines allow him great flexibility in severing hot steel at a relatively low capital cost. The very high cutting speeds necessary to maintain present mill production rates are possible because the stock is at elevated temperatures. Such elevated temperatures not only permit very high cutting speeds, but also allow a wide variation in cutting speeds to suit any mill condition. Therefore, normal variations in rolling mill cycles will not cause difficulties either at the scarfing or cut-off locations.

The mechanization of scarfing on rolling mills was developed early because the advantages of scarfing on large stock and at high speeds were readily apparent. There was no method that could make these advantages possible other than mechanizing the scarfing torch. On the other hand, the need for mechanization of oxygen cutting on rolling mills was not so pressing, because there existed well-developed mechanical severing methods. Therefore, it is only recently that oxygen cut-off machines have been engineered to rolling mill standards.

SCARFING INSTALLATIONS

Present day scarfing machines are complex units with high oxygen and acetylene gas capacity and unique scarfing heads: such heads are supplied, for example, for fixed size bloom scarfing from 4 x 4 to 7 x 7, variable size blooms from 7 x 7 to 14 x 14 and variable size rounds from 7 to 20. The requisite scarfing arms, structures for holding the head in the roll line, control instrument design and gas equipment are unique to the scarfing machine industry. Some idea of the complexity of a scarfing machine installation can be gained from Figure 1, showing the typical elements of a variable size 7 x 7 to 14 x 14-in. installation. It can be noted that in order for the business end of the burner to operate, there are: (1) adjustable arms (2) a smoke and slag shield, (3) operator's pulpit, (4) slag pit, (5) adequate supplies of cooling water, (6) a complete gas system, including: (a) initial oxygen and acetylene source, (b) distribution panels for each, and (c) requisite, high capacity adjustable distribution system from the panels to the tip orifices.

The installation of such major equipment also involves considerable engineering on the part of the steel mill. The responsibility of the mill usually involves supplying the necessary slag pit, roll line control equipment, smoke and slag removal system and any necessary foundations and piping of services to the machine.

It should be noted that, although there are several similarities among all scarfing machines, each new installation must be designed for the particular problem of the particular rolling mill. Thus, it cannot be said that there is a standard scarfing machine installation. In spite of the resulting relatively large investments of time and money by steel mills and manufacturers for such installations, the large number of operating scarf-

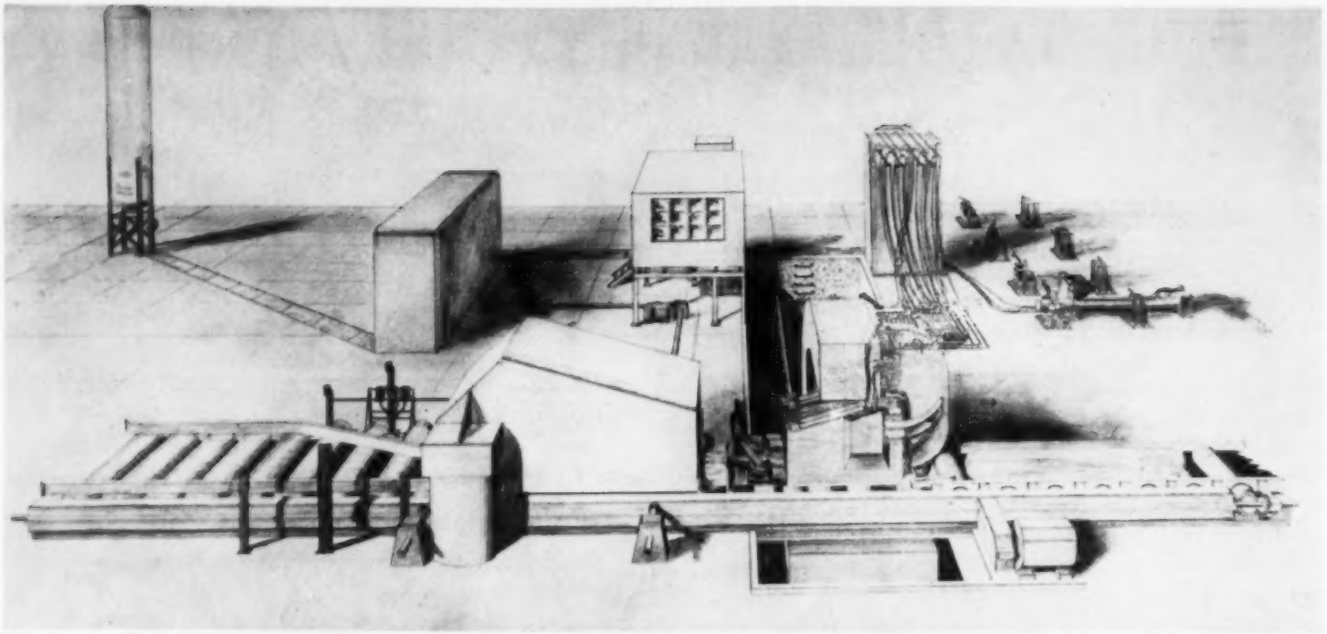


Figure 1 — This is a general layout of a typical adjustable size bloom scarfer showing the main unit, necessary auxiliary equipment and their relationship with the roller line.

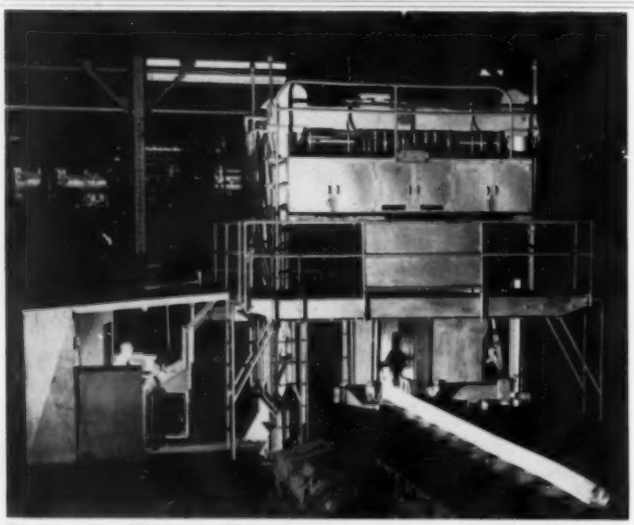


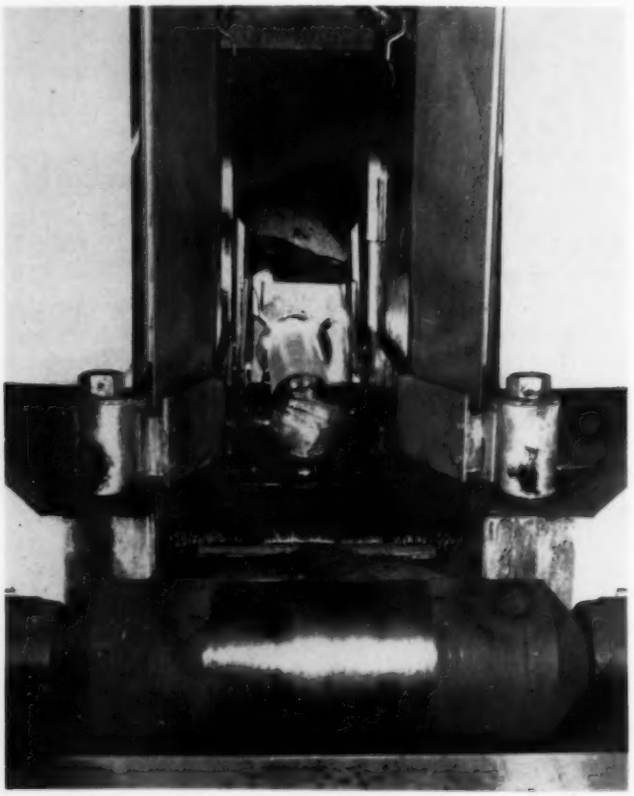
Figure 2 — The scarfing machine shown is the first installation using circular burners to scarf round blooms.

Figure 3 — A circular burner is used for production scarfing of rounds as shown in Figure 2.

ing machines demonstrates the value of the process to the steel industry.

One of the most recent scarfing machine installations in the country is shown in Figure 2. This machine, located in a large eastern mill, is currently scarfing many tons of all grades of steel each month. Thus, there are varied surface conditions ranging from those grades which require little scarfing to such grades as the heavily scabbed high sulphur steels which require deep scarfing.

Figure 4 — A close-up of the scarfing of rounds with the circular burner of Figure 3 is shown from the delivery side of the machine.



Originally this unit was designed to scarf 8 x 8-in. squares but after considerable study, was equipped with circular burners such as shown in Figure 3. So far as we know, this is the first installation in the country to use circular burners. A dramatic close-up of the scarfing of rounds with this circular burner is the view in Figure 4 showing the delivery side of the machine. Interchanging the type of scarfing head for either rounds or squares can be accomplished in about one hour, which is faster than the time required to change rolls. However, the scarfing of rounds has been so successful with particular reference to the resulting surface, and the metallurgical results, that the mill operators are now rolling all products from their mill for scarfing with the circular burners. They have found that the higher quality resulting from round scarfing has increased direct shipments without further conditioning by 20 per cent over that resulting from square scarfing.

Before leaving the subject of scarfing, it is of interest to note that hand scarfing of slabs on delivery tables

Figure 5 — Routine hand scarfing of slabs on delivery table from the blooming mill is an efficient method of removing minor defects.

from blooming mills is also an accepted procedure, as shown on Figure 5. The 72-in. torch length, plus suitable protective clothing and fans, makes such routine hand scarfing operations practicable. This is an efficient method of conditioning slabs with minor surface defects at a minimum capital expense.

It may be fairly stated that machine scarfing of steel at rolling mill temperatures is an indispensable practice in many mills under current operating conditions. Scarfing machine developments during the past 10 years have given the rolling mill operator a rugged tool for the economical production of high quality steel surfaces. Unquestionably, the present production of quality surface steels would be greatly handicapped without the scarfing machine.

HOT-CUTTING PROCESS

The use of oxygen cutting on rolling mills has been done for many years as an emergency measure. Thus,

Figure 6 — An early two-torch set-up for oxygen cutting 6 x 6-in. squares to shipping length is shown.

Figure 6 shows an early application of two torch setup for oxygen cutting of 6 x 6-in. squares to shipping length. Even today, where mills are faced with emergency problems of severance, the equipment used for carrying the torch can be standard cutting machines adapted to the specific job. Such adaptation of standard oxygen cutting equipment to facilitate roll line production is illustrated by the installation shown on Figure 7.

In this installation, the existing hot saw was inadequate to make all necessary cuts for an expanded production program. The addition of the oxygen cut-off equipment shown permits an extremely flexible hot severance cycle. Thus, the 4 x 4 and 4 x 5-in. billets being rolled on the mill are sometimes cut by the hot

Figure 7 — Adaptation of standard oxygen cutting equipment to facilitate roll line production is illustrated by this installation.

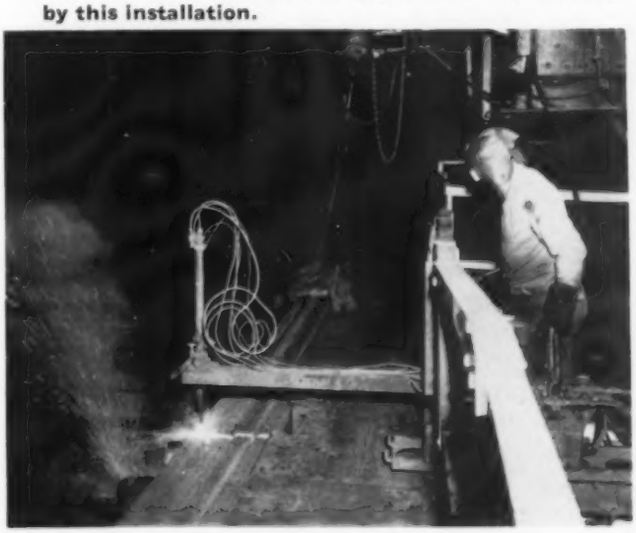


Figure 8 — Quality face of a 12-in., SAE 1020 bloom oxygen cut at 10 inches per minute at 1800 F.

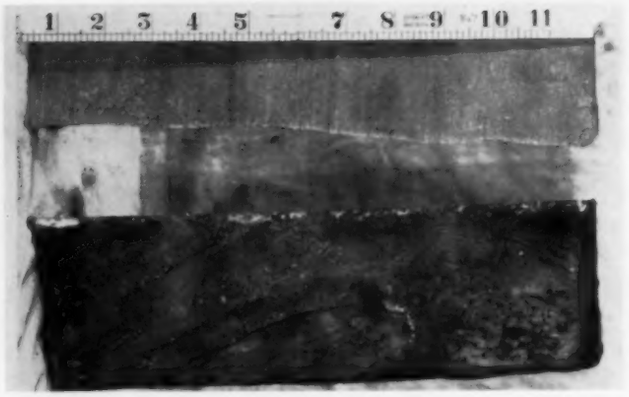


Figure 9 — Severance cut face and profile of a 12-in., SAE 1020 bloom oxygen cut at 32 inches per minute at 1800 F.

saw, sometimes by the oxygen cut-off equipment, depending on hot bed load and other factors. In operation, the billets are rolled against the hydraulic stop shown in Figure 6 and flame cut to length. It is of particular interest that the capacity and dependability of the oxygen cutting installation has maintained production despite hot saw breakdowns.

HOT-CUTTING PROCESS DATA

However, the application of oxygen cutting to rolling mill production with engineered cutting machinery required the determination of extensive process data. Our company, whose interest in flame cutting goes back to the first cutting torch, has been accumulating such process data on hot cutting for many years. A detailed description of some of this data is given in "Oxygen Cutting of Steel at Elevated Temperatures," The Welding Journal, April, 1947, which describes the results of over 3000 controlled cutting tests at elevated temperatures.

Conclusions from these tests of importance to oxygen cutting in rolling mills are:

1. Quality cuts can be produced on steels at elevated temperatures at from two to three times the cutting speeds on cold material.
2. Consistent severance cuts on steel at elevated temperatures can be made at speeds up to seven times those on cold material.

To illustrate the above, Figures 8 and 9 show the cut faces of 12-in. square SAE 1020 blooms, oxygen cut at 1800 F at speeds of 10 and 32 inches per minute, respectively. As can be seen, the cut surface quality of the bloom oxygen cut at 10 inches per minute is equal to any room temperature cut, normally made at 4 inches per minute. The quality of the cut surface at 32 inches per minute is not quite so good, particularly with respect to deviation from vertical. However, since most steels oxygen cut on rolling mills will be subsequently processed, such deviation is of no greater importance than a comparable shear drag.

The general relationship between material thickness and cutting speeds are given in the graph shown as Figure 10. This graph refers to the hot cutting of steel at 1800 F. Curve A for oxygen cutting speeds at 75 F is included in Figure 10 as a reference, showing cutting speeds with which most mill men are familiar. Cutting at temperature ranges higher than 1800 F shows similar relationships between thickness and cutting speeds, but are displaced toward higher speeds at higher temperatures. The curves of cutting speeds at 1800 F are being presented because experience has shown this to be about the usual temperature of steel when it is oxygen-cut on rolling mills.

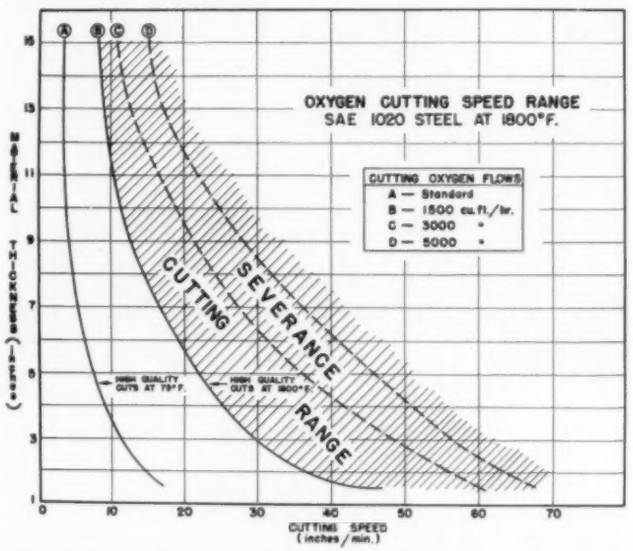


Figure 10 — This graph gives a ready answer to the question of what oxygen-cutting speeds can be obtained under rolling-mill conditions for various steel thickness.

The outstanding characteristic of oxygen cutting at rolling mill temperatures is that very great increases in cutting speeds can be obtained with increasing oxygen flows. Quality cutting speeds at 1800 F for various thicknesses of steel are shown by Curve B; these speeds produce high quality cuts with cutting oxygen flows of about 1500 cfhr. As the cutting oxygen flows are increased, cutting speeds continue to increase in what is designated in Figure 10 as the severance cutting range. Curves C and D for cutting oxygen flows of 3000 and 5000 cfhr indicated that increased cutting oxygen flows produce progressively higher cutting speeds. Such increase in oxygen flows can be obtained to a limited extent by using higher pressures with standard cutting tips. For routine hot cutting, however, it is preferable

to use the larger cutting orifices found in cutting tips especially designed for this heavy oxygen cutting.

Reference to Figure 10 will give cutting speed data for any thickness of steel normally rolled. Thus, the rolling mill operator can get a quick answer to the first question that will occur to him: "How fast can a, for example, 8-in. slab be torch cut?" The curve shows that quality speed for this thickness at 1800 F is 14 inches per minute. However, with doubled oxygen flow of 3000 cfhr, the cutting speed possible increases to 24 inches per minute, and at 5000 cfhr flow, a speed of 32 inches per minute can be obtained. Thus, by regulating his oxygen flows, the operator can consistently produce drop cuts over the wide speed range of 14 to 32 inches per minute. Reference to the graph shows that these high speeds can be increased further. It is true, however, that increases of oxygen flows over approximately 5000 cfhr become less and less economical in terms of speed.

The data given in Table I have been taken from production runs within the last six months to illustrate the range of cutting speeds that will consistently produce severance cuts. The steel being cut is approximately 8½ in. round, of variable analysis, and at an average temperature of 1800 F. Several sizes and styles of oxygen cutting tips were used, giving some variation in preheating gas flows. The major difference between the tips is in the varying oxygen flows each produces.

TABLE I

Cutting Speeds and Oxygen Flows, Production Oxygen Cutting of 8½-In. Rounds

Cutting tip	Cutting speed, inches per minute	Oxygen flow, cfhr
1	20-22	3000-3500
2	19-25	3100-3800
3	24-30	5000-7000
4	28-34	7000

HOT-CUTTING MACHINE DEVELOPMENT

The progressive development of oxygen cut-off machines to rolling mill standards has pointed up the conclusion that cutting equipment which has not been specifically designed for rolling mill applications has generally been found to be lacking in one respect or another. It has been learned that daily use of oxygen cutting equipment in rolling mills puts such severe strains on the equipment that standard oxygen cutting machines do not stand up under the abuse. Furthermore, it has been learned that the disposal of slag and fumes pose problems similar to those of scarfing machines, but on a reduced scale. In short, oxygen cutting machines for rolling mill production should preferably be engineered to meet the job.

A step in such engineering development is illustrated in Figure 11, which shows the production of 685-lb forging slugs from 15-in. rounds, using two simultaneous torch cuts. These slugs had a weight tolerance of minus 0, plus 15 lb. Figure 12 shows a group of slugs which were production cut to these tolerances. Although a standard cutting machine carriage was used for moving the torches, Figure 11 indicates that the

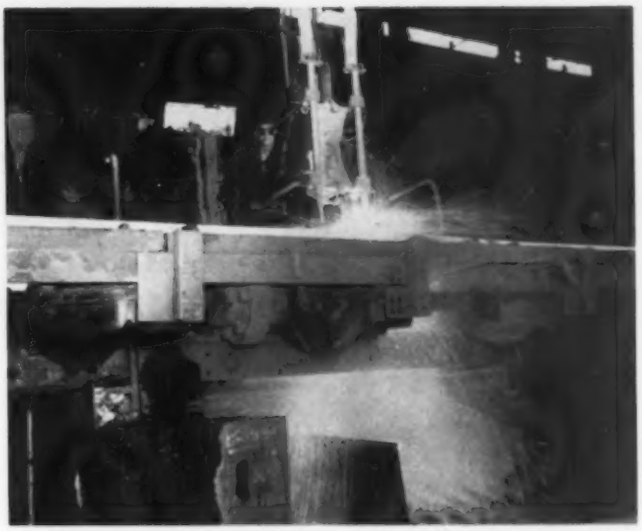


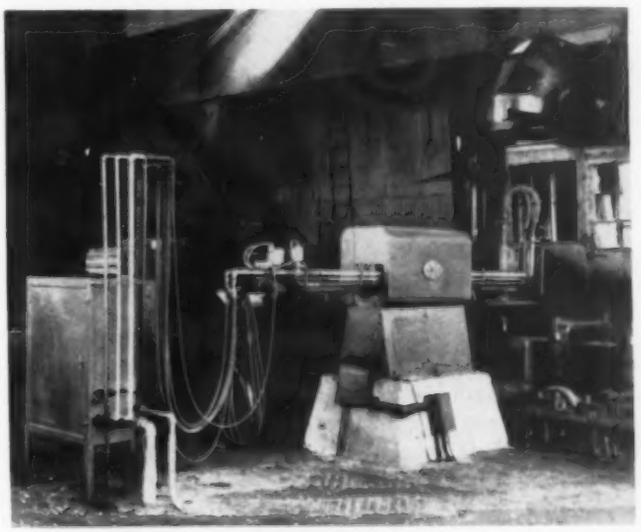
Figure 11 — An early oxygen-cutting installation employed two torches for the production of 685-lb forging slugs from 15-in. rounds.

Figure 12 — This group of 685-lb forging slugs were cut by the installation shown in Figure 11, to a tolerance of minus 0 plus 15 lb.

torch-carrying arms were strengthened and shielded from the heat of the bloom for more dependable performance.

A long step forward to current oxygen cutting machine design was taken with the production unit shown in Figure 13. This machine was installed at the run out table of a blooming mill and gave many years of serv-

Figure 13 — A forward design step in oxygen cutting is this installation permanently mounted at the run-out table of a blooming mill.



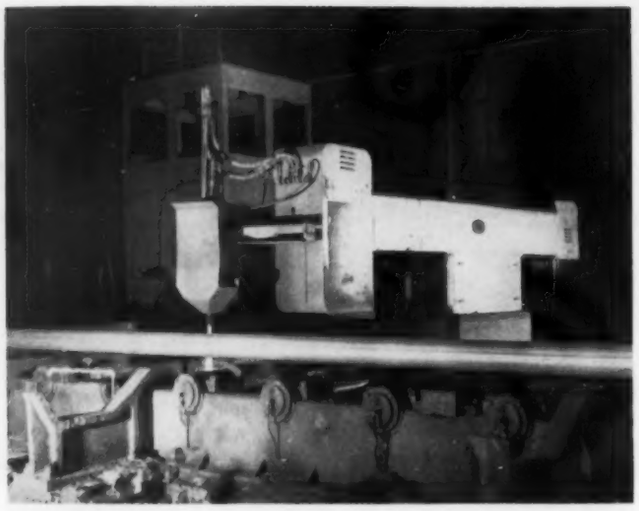


Figure 14 — Consistent 17-second torch cuts in the 8½-in. round shown are made by this recent hot cut-off installation.

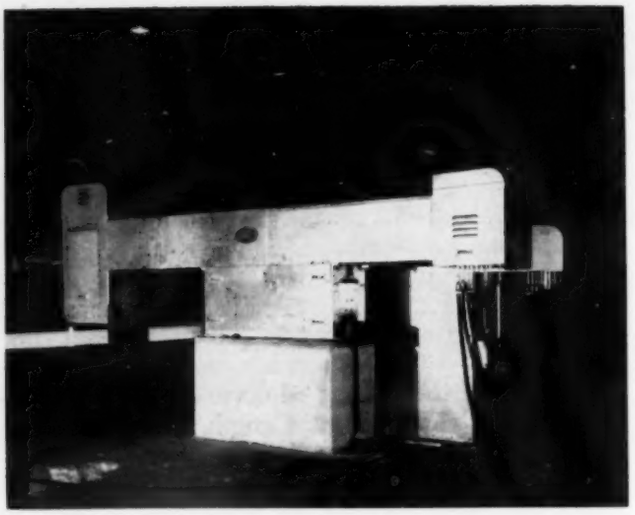


Figure 15 — The entire upper section from torch to service hoses of this hot cut-off machine moves the torch across the roller line with an 80-in. stroke.

ice. It can be seen that the unit is specifically designed for rolling mill service and, as such, is permanently mounted. The torch-carrying mechanism is at some distance from the hot steel for maximum protection from radiant heat. Fuel gases, oxygen, and other services enter the machine from a central cabinet and are controlled by solenoid valves. The bar carrying the torch back and forth over the roller table is driven by an electrical motor. This all-electric control of the machine makes it possible for the operation to be remotely controlled from a mill-type desk. This desk is located on the opposite side of the roller line underneath the fume hood, thus permitting the operator of the hot-cut-off machine to stand far enough from the hot steel to be in a comfortable, safe, working position. Even though he is in a excellent working position, the operator still has an adequate view of the torch and tip, and he has complete control of the cutting operation at all times.

quirement has been readily met, since trial cuts shortly after the machine was installed showed that it is possible to make consistent cuts in as little as 17 seconds.

A front and rear view of this hot cut-off machine, Figures 14 and 15, respectively, show the rugged design of the unit. All moving parts are so thoroughly protected by shields or covers that a first glance conveys the impression of a completely stationary mechanism. Actually, the whole upper half of the machine, from the torch back to the service hoses, is a moving ram which has an 80-in. stroke. This stroke is sufficient to move the torch at cutting speeds completely across the roller table so that the blooms of any size can be cut.

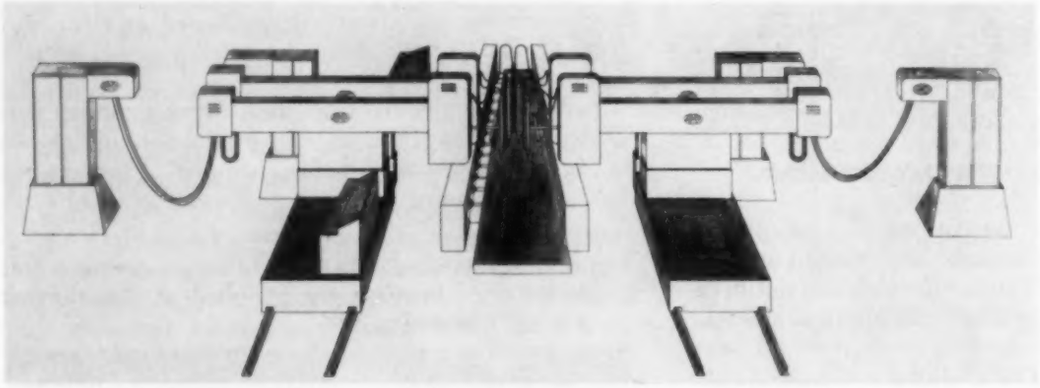


Figure 16 — Hot slabs of variable widths can be oxygen cut at speeds of 60 inches per minute to any length with this installation.

HOT BLOOM CUT-OFF INSTALLATIONS

A further advance in design over the equipment described above is evident in the recent installation of a hot cut-off machine in a large Eastern steel mill. The problem here is to cut long multiples of 8½-in. round blooms to 30-ft lengths on the run-out table from a 30-in. mill without disturbing the rolling mill cycle. Twenty-five seconds are allowed for each cut. This requirement has been readily met, since trial cuts shortly after the machine was installed showed that it is possible to make consistent cuts in as little as 17 seconds.

The machine operator stands in the pulpit shown in the background on Figure 14, with the following controls under his direction:

1. Roller table for positioning bloom under torch.
2. Raise and lower torch.
3. Forward and reverse torch.
4. Preheat gases and cutting oxygen.

In addition to the above electrically-actuated operations, the angle of the torch both parallel and at right angles to the roller table, can be adjusted manually to get the best cutting conditions.

All parts of the cutting machine subject to excessive radiant heat, specifically the torch and the large elevating head at the front of the ram, are water cooled. Operating parts of the machine are accessible through doors for routine maintenance. In addition, a central

lubrication system is provided so that proper care of the machine is easier. Since there are no heavy mechanical loads on any part of the machine, it is anticipated that it will give almost 100 per cent uninterrupted service.

The working part of the machine is the torch and tip, neither of which is subject to any mechanical load. Since the cutting tip clearance above the steel is from 1½ to 2 in., there is very little fouling of the tip from flying scale. A cutting tip can be changed in a few minutes, and the entire cutting torch can be changed in 10 minutes if it should accidentally become damaged.

The outstanding advantage of oxygen hot cut-off is this almost 100 per cent availability of the tool. With a minor stock of maintenance parts and a minimum of routine maintenance, there is every reason to anticipate that such a cut-off machine will be available at all times for work so long as there is an adequate supply of oxygen and fuel gases.

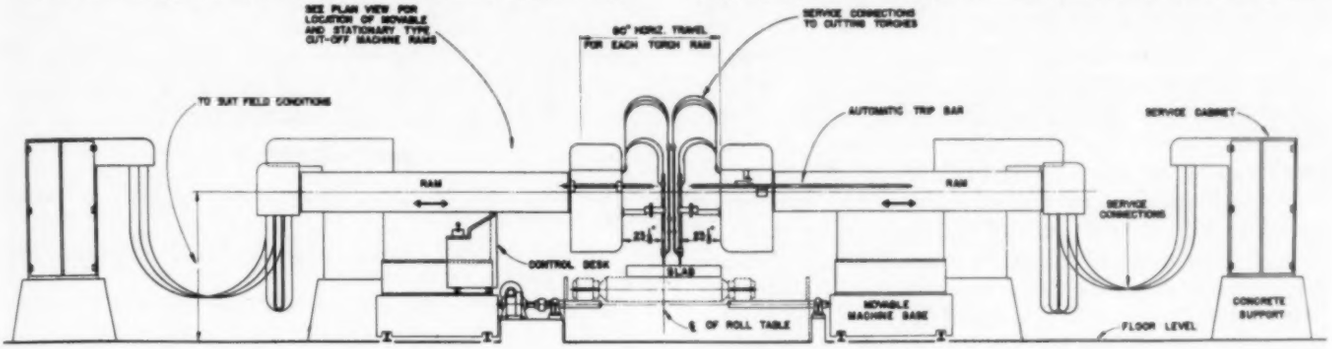


Figure 17 — A single cut is made by having two torches start simultaneously from opposite sides of the slab. One torch automatically retracts from near the center of the slab while the second torch finishes the cut.

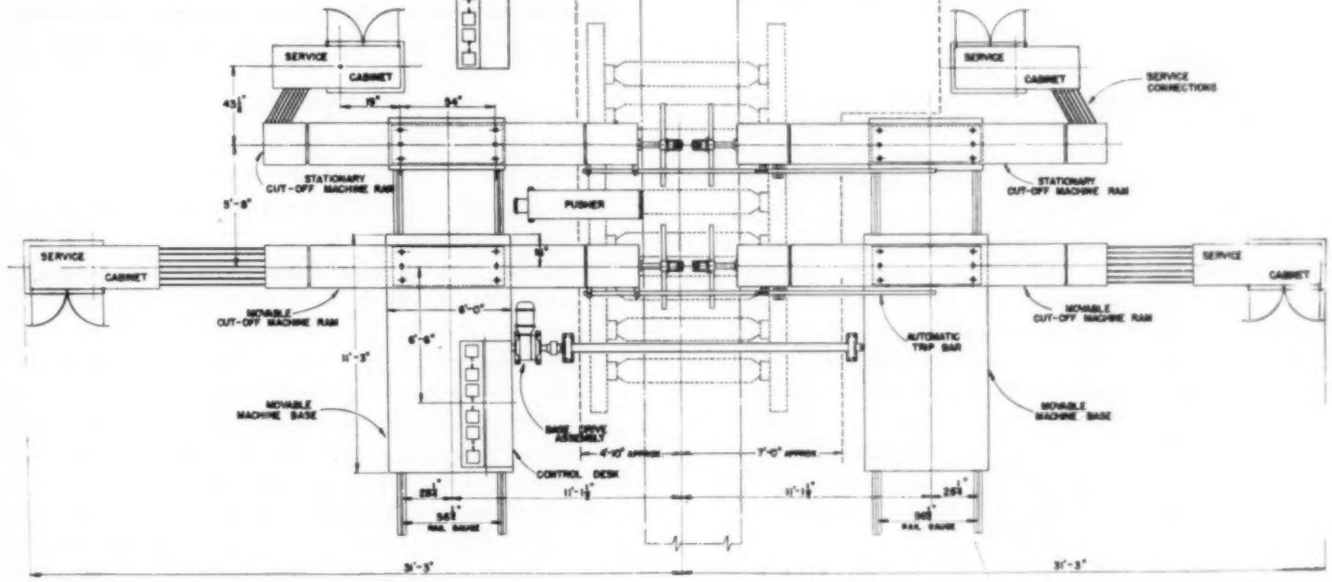


Figure 18 — Various slab lengths can be cut by moving the lower pair of torches away from the fixed upper pair.

HOT SLAB CUT-OFF INSTALLATIONS

It was this same important question of operating dependability of hot cut-off equipment which prompted a steel mill to ask for a design of hot slab cut-off machine. It is a known fact that a high production slab and strip mill must operate at a near maximum rate in order to be profitable. Since breakdowns of mechanical shears are unpredictable and frequently involve a lengthy shutdown, the steel mill operator is keenly interested in the almost perfect operating availability of oxygen cutting equipment.

The first question to be answered is the potential speed of an oxygen cut-off machine. The data, as summarized in Figure 10, show that for ordinary slab thicknesses of 4 to 6 in., single torch cutting speeds of 30 inches per minute are easily possible. The use of two torches making the same cut simultaneously will give an effective cutting speed of 60-in. per minute, and make oxygen cutting more than fast enough to keep up with the slabbing mill cycle.

Accordingly, the largest hot cut-off machine to date has been designed for the oxygen cutting of slabs. The general arrangement of this hot slab cut-off machine is shown in Figure 16, while Figures 17 and 18 show a front and plan view to illustrate some of the operating details. In general, the machine consists of two opposed pairs of units, each similar in design to the unit shown

in Figures 14 and 15. One of the opposed pairs of torch-carrying units is stationary; the other is movable along the roller line. This machine cuts slabs up to 74 in. in width, of any thicknesses, and to any desired length. The cutting speeds are twice that of a single torch, since the two opposing torches of a pair are designed to make the same cut by starting towards each other simultaneously from opposite sides of the slab. During a cut, the two torches approach each other to within a few inches. At a predetermined distance, the automatic trip bar first stops and then retracts one of the torches, and the other torch finishes the cut.

Since the desired lengths of slabs can be extremely variable, the second pair of torch-carrying units is mounted on a set of movable bases. These bases are driven by a common drive assembly so that, as the pair of torches move back and forth along the roller line, they will always be directly opposite each other.

Preferred practice is for a single operator to run one pair of torches making a single cut. The control desk for the stationary units is shown at floor level, and the control desk for the movable units is shown on one of the movable machine bases. It is quite possible to locate all controls in a pulpit which straddles the roller line if such location is considered advisable for a particular installation.

The front view and plan of the hot slab cut-off installation show its important dimensions. It should be noted that each torch has 80 in. of horizontal travel, so that a single torch can cut the entire width of the slabs if required. The height of the machine is determined by field conditions. The width of the machine, including service cabinets, is 31 ft 3 in. on each side of the center line of the roll table. The length of the machine is variable, depending on the cut lengths of the slabs; minimum length with the two pairs of torches in the closest position is about 25 ft; maximum length can be anything to suit the mill conditions. Some flexibility exists in possible location of the gas control cabinets and control desks, so that the indicated dimensions can be changed somewhat if a particular mill condition requires other dimensions.

Accumulated steel mill experience with oxygen hot cut-off machines of smaller size than this slab unit has demonstrated the advantages of the high operating availability and relative flexibility of these machines. Since this high operating availability will minimize shut-downs now experienced from major shear breakdowns, resulting savings will quickly repay the investment in the oxygen cut-off unit.

SUMMARY

The development of oxygen cutting from routine hand maintenance to engineered machines for standard rolling mill production applications has progressed in two major directions: (1) machine scarfing, and (2) oxygen hot cut-off machines. The present day rugged high capacity machines for both operations are engineered from extensive background in oxygen cutting at rolling mill temperatures. The cutting data point up the fact that any particular thickness of steel can be consistently hot-cut at a wide range of speeds, depending primarily on the oxygen volume used.

The practical nature of this fact is shown by the numerous scarfing and hot cut-off machines which have been designed and installed to meet specific mill requirements. The recent round scarfing machine and round hot cut-off machine installations and the hot slab cut-off machine are outstanding examples of current oxygen cutting equipment. These most recent designs give the rolling mill engineer sturdy machines of high production dependability which greatly expand his choice of finishing and severing methods.

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DISCUSSION

PRESENTED BY

WARREN H. JOHNSON, Chief Engineer, Colorado Fuel and Iron Corp., Claymont, Del.

R. L. DEILY, Steel Mill Representative, Air Reduction Co., New York, N. Y.

J. WARD PERCY, Supervisor, United States Steel Corp., Kearny, N. J.

W. H. Johnson: I would like to know how much the last setup shown would actually cost.

R. L. Deily: The four-torch machine for oxygen cutting slabs to length would cost in the neighborhood of $180,000 not including installation.

Member: Have any of these installations used natural gas as a fuel instead of acetylene? Have any of these cutting applications been made on light gage material? I am speaking in terms of plates.

R. L. Deily: Natural gas can usually be used for cutting. I have mentioned acetylene because I think its use is customary, but natural gas can be used without difficulty. As far as light gage plates are concerned, I suppose you mean about one-half inch to one inch. Oxygen cutting machines have not been used on light material in production hot cutting because it is relatively much easier to shear lighter material. There is no reason why it could not be done. Again, you would have to look at the installation and see what all the ramifications of cost are.

J. Ward Percy: Looking from the standpoint of research and development, this paper presents a pretty good illustration of what can be done with a comparatively simple idea, and 20 years of time and effort. What has been done has been highly important. Certain types of materials could not have been rolled, or the type of surface or lack of decarburization could not have been produced to meet consumer's specifications had it not been for the use of hot scarfing methods.

DIRECT ROLLING OF CARBON STEEL INGOTS TO PLATES ON THREE-HIGH AND FOUR-HIGH PLATE MILLS

By ROBERT C. McMICHAEL
Supervisor 112-120-in. Mill
Lukens Steel Co.
Coatesville, Pa.

. . . . operations show that the four-high plate mill has many advantages over the three-high unit . . . .

▲TWENTY years ago, and in some cases even today, when the management of a steel company asked a plate mill superintendent to roll a plate to a width approaching that of the mill, particularly if it was light gauge, the superintendent would start worrying and immediately line up a series of precautionary measures that would have to be taken if the order was going to be produced with any degree of success, that is, if he was unsuccessful in discouraging management from accepting the order. Generally speaking, the mill superintendent was justified, for the three-high mill in use at that time presented serious problems which were not overcome until the modern four-high mill came into use. Since 1917 when Lukens installed its four-high, 206-in. mill, the mill personnel have been studying the techniques of rolling plates on four-high stands as contrasted to those used on three-high stands. Much was learned, and when the demand for plates greatly increased in the early war years, a modern 120-in. mill was installed in line with the then producing 112-in. three-high mill.

It might be well to explain some of the reasons why the writer chose to discuss this particular subject. There are two commonly used methods for rolling carbon steel plates: (1) direct rolling from ingots; and (2) rolling the plates from slabs that have been rolled from a large ingot on a slabbing mill, conditioned, and cut to desired length prior to final rolling. Both methods are practical and produce good quality plates. The method adapted is usually that which is most suitable for the type of market that is to be satisfied as well as the equipment that is available for the production of the ingots and the slabs or plates. The two methods require manufacturing techniques that differ considerably not only in the open hearth but in the mills as well. Because of these differences in techniques, as well as the differences that exist from one mill installation to another, the writer has chosen to confine his comments to the direct rolling of ingots to plates on the three-high and four-high mills that are currently in operation at Lukens.

DIRECT ROLLING PRACTICE AT LUKENS

The present practice at Lukens of direct rolling ingots to plate is one that has been developed over a great many years. It is a practice that has been found to be particularly adaptable to the production of specialty orders and for the production of a great variety of plates, i.e., by gauge, width, length, and quality. Some people may question why this practice has been considered most desirable. Some of the reasons for this decision are as follows:

1. It permits the mills to keep operating on plate production with a minimum of inventory.

2. A higher yield of prime plate has been obtained at Lukens by direct rolling rather than by slabbing and subsequent rolling of slabs to plates.
3. The need for a slabbing mill is eliminated.
4. This practice gives maximum flexibility and is therefore particularly adaptable to the handling of specialty orders.

In order for this practice to work satisfactorily and produce a high quality product off the mills with a minimum of rejections, it has been found necessary to employ a bottom pouring practice in our open hearth department. This enables the open hearth to produce an ingot which has an extremely good surface, with a minimum of sub-surface porosity, localized porosity, etc. Considerable cooperation, however, must exist between the open hearth and mills to achieve maximum benefit from this practice for a number of reasons. One of the prime considerations is ingot design which must be suitable from the open hearth quality standpoint and still be suitable for rolling on the mills at a maximum production rate with good quality and high yield. There are a number of problems confronting the open hearth that will not be considered in this paper. However, it should be pointed out that a large number of varying mold sizes must be employed to cover the complete range of plate production at Lukens.

At the present time there are 18 different mold sizes employed. These are given in Table I. It might be well to state that although this list might seem to be quite lengthy, there are fewer ingot sizes now employed to service our present mill facilities than were used several years ago, and a drastic reduction from what were used when our universal mill was in operation.

TABLE I

Mold Sizes Employed in Direct Rolling at Lukens

29 x 9	47 x 11	70 x 23
32 x 12	48 x 17	70 x 30
35 x 15	48 x 21	80 x 30
39 x 9	54 x 23	90 x 34
43 x 16	60 x 17	90 x 40
46 x 9	60 x 21	108 x 40

There are a number of things that must be considered from the mill standpoint when thinking of the proper ingot size for a given range of plates. The ratio of ingot thickness to final plate thickness must be great enough to have sufficient work on the ingot to clean it properly and get a good structure in the finished plate. The ratio of 12 to 1 is held to as closely as is practical. The width of the ingot is another factor to be considered. It should be made as wide as possible. This is limited by open hearth considerations as well as the amount of cross rolling that is necessary to give the desired physical properties in the final plate. The length of the ingot should not be any less than the width if at all possible. The length is usually limited by both mill and open hearth considerations.

Considerable progress has been made by our open hearth department along these lines. It used to be common practice to roll light gauge plates from short, chunky ingots. This resulted in slow rolling on the mill and a low yield. By giving this matter a lot of thought, our open hearth has been able to produce good quality rimming and killed steel ingots in sizes that have a ratio of width to thickness as high as 5 to 1. This has permitted our mills to produce light gauge plates ($\frac{3}{16}$ to $\frac{3}{8}$ in.) at a much higher production rate, a higher yield, with no sacrifice of quality.

The subject of ingot weight is naturally important in the direct rolling practice. It is obvious that if the ingots are poured too short, the mills will not be able to produce the desired plates. If the ingots are poured too long, the overall yield will be drastically reduced. It also has a direct bearing on the tonnage produced by the mill.

While discussing the relationship of the open hearth and the mills in making the direct rolling practice work satisfactorily, the question of quality and percentage of defects naturally comes to mind. The percentage of material that had to be rejected due to various types of defects after having been rolled to plate are given in Table II. These defects are broken down in the various categories and separated by the department responsible. The open hearth department is held responsible for such things as scabs, laminations and blisters, seams, snakes, hollow top, spongy, pits, etc. The figures given in Table II are averages for the year 1952. It is obvious from these figures that the defects are not prohibitively high.

In the direct rolling practice it is absolutely necessary that the open hearth's and mill's production schedule be closely coordinated, particularly when producing large sized ingots that must be charged hot because of quality considerations. Each ingot must be carefully inspected and conditioned to remove any material that would present a hazard in the rolling operation. This part of our operation is handled by the production control department. Every effort has been made by both the open hearth and the plate mill departments to standardize their practices, so the production control department might coordinate their activities to achieve the most satisfactory overall production.

From the standpoint of the mill's operations, standards have been established for each heating unit by ingot size, as well as maximum and minimum lengths. Along with these standard charges, corresponding heating times have been established, so the pits and furnaces may be charged in such a way as to keep "Nothing Hot" delays to a minimum. Standards have been established on each mill regarding the correct procedure for scheduling plates by width and gauge in order to produce good quality plates with a minimum of delay time. Correct standards for provision are adhered to by the mill providers working in the production control department. This man must pay particular attention to the length, width, and gauge of the plate, the ingot size from which it is going to be rolled, and the mill that is going to roll it, i.e., a three-high, old four-high, a modern four-high mill or any combination of the types of mills.

DEVELOPMENT OF MILL FACILITIES AT LUKENS

With this brief explanation of the relationship between the open hearth and the plate mills and how they are coordinated by the production control department

TABLE II

Defects Encountered in Direct Rolling

Open hearth	112-120-in. Mill comb.	140-206-in. Mill comb.	Mill	112-120-in. Mill comb.	140-206-in. Mill comb.
Scabs	0.38	0.15	Cinder and scale	0.12	0.05
Laminations and blisters	0.34	0.82	Burnt	0.01	0.09
Seams	0.28	0.23	Seams (1)	0.01	0.01
Snakes	0.42	0.66	Gage	0.27	0.17
Hollow top-piped	0.51	0.09	Narrow	0.04	0.01
Spongy	0.16	0.05	Wide and short	0.03	0.09
Pits	0.06	0.01	Cobbled	0.11	0.02
Miscellaneous	0.06	0.03	Overroll	0.12	0.29
			Cold pieces	0.17	0.06
	2.21	2.04	Laid out wrong	0.02	0.02
			Spoiled at shears	0.23	0.03
			Miscellaneous	0.24	0.22
				1.37	1.06

Total all defects ..... 112-120 in. mill comb.—3.58
140-206 in. mill comb.—3.10

Average ingot weight during 1952 120 in. mill—4980
140-206 in. mill—14500

in making the direct rolling practice a successful one at Lukens, it is desirable that a little background be given on the development of the present mill facilities at Lukens.

From the start of its operations in 1810, the management of Lukens has been primarily interested in the production of plates and plate products. The history of our mills follows closely the improvements in plate mill design and plate mill practice made throughout the country. The first mill at Lukens was a two-high mill, with rolls 48 in. long, approximately 18 in. diameter, and driven by an over-shot waterwheel. Later the over-shot waterwheel was replaced by a breast wheel geared to convey more power to the rolls, and later a flywheel was added. This permitted larger rolls to be used (66 in. long x 21 in. diameter). This mill operated until 1870 when a steam driven, two-high, 84-in. mill was put into operation. About ten years later a three-high, 84-in. mill was added to work in conjunction with this mill.

In 1903, a 120-in. three-high mill was installed. This mill was the largest of its kind at that time in the country. In 1912, a three-high, 140-in. mill was put into operation and was followed in 1917 by a four-high, 206-in. mill. This latter mill was a forerunner of our present day four-high mill and greatly advanced the production of high quality plate in our country.

Every effort has been made over the years to investigate the various phases of plate production and a number of mills have been installed after due consideration, and have either withstood the test of our changing economic picture or have been eliminated or modified as business required. As late as 1941, Lukens had five plate mills in operation. At that time, plans were started to consolidate production into two primary producing units. The result of this study was the elimination of the universal mill and the 84-in. mill, and the consolidation of the three-high, 112-in. mill with a new four-high, 120-in. reversing mill. This consolidation has resulted in a far more efficient operation without any decrease of production. Our three-high plate mills are now being used largely as roughing stands for the four-high mills. However, plates are still produced on the 140-in. mill when the situation demands.

PRESENT MILL FACILITIES AT LUKENS

Although our present mill facilities have been quite adequately covered in the following papers ("Lukens —Pioneer in Plates and Plate Products," by T. J. Ess and I. E. Madsen, Iron and Steel Engineer, May 1946) and ("Production of Plates," by W. L. Bunting, Steel, May 30, 1949), the following mill information is reviewed for subsequent discussions.

One of the two main plate producing units at Lukens today is the 112-120-in. mill combination. This is a combination of a three-high 112-in. mill, which was a plate producer until 1943 and now serves as a rougher for a new 120-in. four-high stand. The 112-in. mill is driven by a 3750-hp, wound rotor induction motor, operating at 2200 volts, 500 rpm, driving through a reduction set of 5.61 to 1 giving a speed of 90 rpm at the lead spindle. The pinion stand further reduces the speed at the mill to 45 rpm. The top and bottom rolls in this mill are cast iron, grain type rolls with 112-in. body length x 36-in. diameter and necks 26 in. diameter x 21 in. long. The middle roll is a grooved cast steel roll, 112 in. long x 21 in. diameter, with 14 in. diameter, 21 in. long necks. The rolls operate in bronze bearings with forced feed lubrication. The screws are 11 in. diameter, with 1¼-in. pitch threads.

A vertical edger is located approximately 40 ft in back of the 112-in. mill which contains rolls 42-in. in diameter, with a 28½-in. operating face. A maximum opening of 120-in. is available. The drive is a 1250-hp, 600-volt, 70-210 rpm, d-c motor. Power for this motor comes from a 1000 kw motor-generator set.

The 120-in. mill is driven by a 7000-hp, d-c reversing motor, with possible speed variation from 35-80 rpm. This motor is serviced by d-c motor-generator set comprised of a 6000-hp, 13,200 v, a-c motor driving three 2000-kw, 700-v, d-c generators. An integral vertical

edger is located in front of this mill. The edger rolls are 24-in. in diameter with a 10-in. working face. They are driven by a 500-hp, 700-v, 200-500 rpm, d-c reversing motor. The vertical rolls are adjusted in a horizontal direction by two 25-hp motors. The work rolls for this mill are alloy cast iron of the grain type, having a barrel length of 120 x 36½-in. diameter, and necks 24 in. diameter x 39½ in. long. These rolls operate in roller bearings. The back-up rolls for this mill are cast alloy steel with a barrel length of 120 x 54-in. diameter and tapered necks approximately 37½-in. in diameter, operating in oil film bearings. The rolls are balanced by an oil-hydraulic system. A maximum roll lift of 15 in. is available. The mill screws, 20-in. in diameter with a 1-in. pitch, are operated at a lift speed of 12 in. per min by two 75-hp motors under magnetic contactor control which is automatically interlocked with other mill motions. An automatic preset screwdown is available for use by the mill operator. This automatic preset screwdown was thoroughly explained in the paper ("Operation and Maintenance of Automatic Preset Plate Mill Screwdown Control" by J. F. Skalka and R. G. Uhler, Iron and Steel Engineer, 1948).

A descaling system operating at 1350 psi is located on the back of the mill with sprays to cover both the top and bottom surfaces of the plates.

This mill will produce plates up to 108-in. pattern width x 3/16-in. minimum gauge and will handle a maximum ingot weight 18,000 lb. The 112-120-in. mill is serviced by five, two-hole rows of top fired recuperative pits, and five side door heating furnaces—four of which are of the recuperative type and one of the regenerative type. Natural gas is the normal fuel for these units, although fuel oil can be used with a few minor adjustments.

The three-high, 140-in. plate mill is driven by a 4000-hp, wound rotor induction motor operating at 13,200 volts, 397 rpm, driving through a reduction set of 5.61 to 1 giving a speed of 67 rpm at the lead spindle. The pinion stand further reduces the mill speed to 40 rpm. The top and bottom rolls are 38-in. diam with barrel length of 140-in., 28-in. diam necks x 22-in. long. The middle roll which is fluted when the mill is being used as a rougher for the 206-in. mill is 22-in. diam x 140-in. barrel length, 15-in. diam necks x 22-in. long. Maximum opening between rolls is 23 in. The rolls are hydraulically balanced. The mill screws are 10-in. in diam with 1¼-in. pitch and are driven by one 60 hp motor. The roll necks run in bronze bearings with forced feed lubrication. A descaling spray system operating at 750 psi is attached to the back of the mill.

The four-high, 206-in. mill operates with a twin-motor drive. Each spindle is driven directly by a 4000-hp, separably excited d-c motor operating at 600 volts, and at speeds varying from 35 to 75 rpm. The backing rol's for this mill are 50 in. diameter x 206 in. barrel length with necks 36 in. diam x 31 in. long. They are of alloy steel. The working rolls are 34 in. diam x 206 in. barrel length with necks 26 in. diam x 28 in. long. All the bearings are bronze, except the bottom bearing on the top work roll where a composition bearing is employed. The maximum roll lift is 42 in. Two 150-hp motors operate the mill screws which are 16 in. in diameter and of 2-in. pitch. The rolls are hydraulically balanced. A 1300-psi hydraulic descaling spray system is connected in back of the mill for cleaning the top and bottom surfaces of the plates.

In the 140-in. mill building, there are four furnaces of two holes each, of top-fired, recuperative type pits with rated capacity of approximately 100 tons per hole. There is also one furnace of three holes of top-fired recuperative type. Adjacent to the 206-in. mill building are two furnaces of two holes, each of regenerative type, and five furnaces of three holes, each of regenerative type. There are also four furnaces of two holes, each of top-fired recuperative type, making a total of 38 pits servicing this mill. These pits are all fired normally with natural gas.

IMPORTANCE OF PROPER HEATING PRACTICES

Before discussing the effect of mill design and/or practice in the production of good quality plate, it might be well to mention the importance of proper heating. Regardless of the type of mill or mills being employed, a mill can only perform at its best when the material being rolled has been thoroughly soaked at the correct rolling temperature before rolling. Some use is made at Lukens of a rule of thumb of one-half hour per inch of ingot thickness. However, this must be modified to take into consideration the charged weight in relation to the capacity of the heating unit, the charging pattern, the height of the ingots in relation to the burners, as well as the characteristics of the heating unit being employed and the temperature of the steel being charged.

When rolling ingots direct to plate, it has been found desirable to have a loose jacket of scale on the ingots when they are drawn from the heating unit. This jacket should fall off when the ingot is placed in the ingot buggy. It serves to remove minor surface imperfections that might be on the ingot. If rolling is attempted on an ingot with one cold face, the cold face will not draw out as fast as the hot one, with the result that the ingot will curl in the direction of the cold face. A condition of this kind often results in broken equipment or a cobble. Ingots with a non-uniform heat from top to bottom may be the cause of a broken roll or excessive end to end variation in gauge. Under-heated steel may be the cause of excessive oxide, cobbles or off gauge plates as well as possible mechanical difficulties. Over heated steel usually results in excessive cinder, localized seams, and broken edges on plates and possible scrapping of the entire heat.

COMPARISON OF THE CHARACTERISTICS OF THREE-HIGH AND FOUR-HIGH MILLS

When comparing the rolling of plates on three-high and four-high mills, one must take into consideration the characteristics of the two types of mill design. The three high mill is to a certain degree a backed-up mill, since the middle roll is smaller than the top and bottom rolls and you have the advantage of the middle roll being backed up by either the top or bottom roll. How-

ever, the difference in the pressure being exerted on the opposite faces of the material being worked is exaggerated by the difference in the diameter of the middle roll as compared to that of the top and bottom rolls. This in itself has been found undesirable at Lukens for several reasons. One is the uneven over-roll that is produced by the three-high mill. This uneven over-roll is probably produced by a combination of factors: (1) the difference in pressure being applied to the opposite faces of the material being worked; (2) the middle roll is driven by friction and often lags instantaneously in back of the driven roll; (3) the entry angle of the piece into the mill off the tilting tables; and (4) the uneven drafting on the top and bottom passes that is necessary at times. This over-roll condition represents a loss of possible yield in prime plate.

The small diameter middle roll also limits the amount of draft that is possible to put on an ingot in the mill. If an excessive draft is used the middle roll will often lock which might result in mechanical difficulty. When rolling heavy gauge ingots on a three high mill, care must be used with regard to the draft on the top pass for several reasons: (1) the angularity of the vibrating spindle reduces the efficiency of the coupling between the spindle and the roll to the extent that a heavy draft on the mill may result in a broken coupling box or a broken roll neck; (2) if the draft is not heavy enough to result in trouble at the coupling box, it may still be heavy enough to cause the back end of the ingot to be picked up off the table. As the ingot proceeds through the mill, the back end of the ingot is brought back onto the table with considerable force and may result in broken table rollers or table brackets. This trouble is caused by the difference in the diameters of the top and middle roll combined with the entry angle of the piece off the tilting tables. The tilting tables used in conjunction with the three-high mill often prove to be a source of trouble in the operation of the mill. With the tilting table you have an angularity of entry of the piece in the mill. This angularity may be all put on the top pass (as it is on our 140-in. mill) or may be divided in some manner between the top and bottom passes (as it is on our 112-in. mill). The tables must also be maintained at the proper level in relation to the mill in both the "down" and the "up" position if trouble is to be avoided.

The speed of raising and lowering the tilting tables should be closely synchronized with the raising and lowering of the middle roll. If this is not achieved, productivity can be reduced considerably and frequent mechanical failures will occur. Since the synchronization is carried out by the table operator, there is always a possibility for human error. One of the most common occurrences is "jumping" the middle roll. This is caused by the failure of the operator to have the middle roll against the supporting roll before the piece is entered in the mill. This can result in a broken roll or chuck, or bent stilyards. Occasionally the table operator will work faster than the screws will operate. This will cause the piece to be entered in the mill before the screwman has arrived at his desired draft. This results in the use of extra passes, i. e. lost productivity and may result in a cobbled plate. The table operator may on occasion raise the tables before the piece is completely out of the mill and cause damage to the front part of the tables.

The tilting tables on a three-high mill often are a handicap in rolling plates near the maximum width of the mill. Some of the reasons for this are: (1) it is extremely difficult to employ adjustable side guards on the entry and exit side of the mill to keep the plate in the center of the mill at all times—these side guards are practical and are commonly used on the stationary tables of a four-high mill; (2) the tilting tables will often cause the plate to run in the mill because of the entry angle of the plate—if the plate is longer than the tilting table, the back end will often throw it out of the center of the mill.

The tilting tables on a three-high mill often limit the weight of the piece that can be rolled on the mill. Their construction must be strong enough to withstand the various stresses that are put on them, but at the same time, if they are made heavy enough to handle extremely heavy ingots, they become unwieldly and too slow for the proper handling of smaller ingots. This trouble is not encountered on the four-high mill where the tables are stationary and the weight of construction has little or no restriction on the production rate.

By the nature of their design, our three-high mills are constant speed and non-reversible, powered by a-c induction motors with flywheels to equalize the peak loads. In such a combination the fly-wheel carries most of the load on short passes, and the motor carries most of the load on long passes. The choice of base operating speed on a three-high mill is extremely important for it represents a definite compromise between the most desirable speed for the break-down passes as against the most desirable speed for the finishing passes. It is well known that the first several passes given an ingot should be light in order to pack the ingot structure. Following these saddening passes, it is desirable to put heavy drafts on the ingot at a low speed. As the processing of the ingot continues and the plate is in the finishing stages, it is desirable to increase the speed of the mill and decrease the percentage of reduction on the plate. It has not been found practical at Lukens to vary this speed on the three-high mill during the course of rolling a plate; therefore, the compromise is made between the desired slow speed for the early passes and the desired high speed for the finishing passes.

This constant speed, non-reversing characteristic of the three-high mill also is a limiting factor for the maximum length and width of the plates that can be rolled. When rolling a plate near the maximum limitations of width on a plate mill, a mill supervisor will cut down the length of the plate. This reduction in length will be more drastic on a three-high mill than on a four-high mill for several reasons: (1) if the plate should run in the mill, the non-reversible drive on a three-high stand does not give the protection to the mill that is possible on a reversible four-high mill; (2) the slow speed during the finishing passes causes a considerably lower finishing temperature. The greater variation in gauge from end to end as well as edge to center of the plate in the three-high mill as compared to a four-high mill will also be influencing factors in determining maximum length and widths that can be rolled.

It may be interesting to note the improvements that may be obtained in maximum lengths obtainable off a four-high mill as compared to a three-high mill. Table III gives a comparison of the maximum rolling pattern lengths off the single 112-in., three-high mill, as compared to the same mill acting as a rougher for a modern 120-in. mill. It should be made clear that the improvements shown are not due only to the four-high mill but also due to the fact that the two mills are working together as a unit, and therefore, work the ingot faster.

In the actual rolling operation, the object is, of course, to produce a plate as near perfect as possible at a high yield and a reasonable rate of production. In order to do this the following ills must be avoided:

1. Cinder and Oxide.
2. Off gauge.
3. Buckles.
4. Heavy center.
5. Narrow.
6. Wide and short.

Cinder and oxide can naturally be caused by poor heating as previously mentioned. However, the mill operation can do much to eliminate this source of trouble. Due to the characteristics of the three-high mill, the finishing temperature is usually lower than on a four-high mill for like material, particularly light gauge plates. There is a natural tendency to refrain from the use of too much descaling water on the three-high mill for this reason. Burlap bags and salt are often substituted for this water. Both of these materials have been found to cause mechanical difficulties. Despite the use of salt and burlap combined with 750-psi water in descaling headers, it is difficult to produce blue light gauge plates free of scale on the three-high mill. It has been found possible to eliminate the use of salt when rolling plates on the four-high mill. This is due primarily to the increase in pressure on the descaling headers to 1300 psi and the ability to use the spray more frequently because of the higher finishing temperature. The surface condition of the plate is also improved. The use of burlap is eliminated when the three-high mill, using a fluted middle roll, is combined as a rougher for the four-high mill. The only limitation that has been found in the amount of pressure that can be used on the descaling sprays on the four-high mill is the fact that if the pressure is increased too high, a condition resembling a sandblasted surface is developed on the plate.

Off gauge material can be caused by improper heating as previously brought out. However, it may also be caused by the inattention or possibly the inexperience of the screwman. The screwman is guided in his operation by a micrometer dial graduated in fractions of an inch which indicates to him the opening of his

TABLE III

112 and 120 In. Mill Rolling Lengths (Pattern)

Mill,	Width,	3/16 In.		1/4 In.		5/16 In.		3/8 In.		7/16 In.		1/2 In.		5/8 In.	
in.	in.	In.		In.		In.		In.		In.		In.		In.	
112	63	360	1625 20x9	400	2425 24x10	480	3525 32x12	480	4225 34x13	480	5000 36x15	480	5725 36x15	460	6850 42x16
120	63	600	2650 38x8	700	4100 45x8	800	5800 36x15	800	6875 42x16	800	8000 42x16	800	9150 48x17	800	11450 48x17
112	82	360	2150 24x10	400	3175 28x12	480	4650 34x13	480	5600 36x15	480	6600 36x15	480	7550 42x16	430	8450 42x16
120	82	600	3450 45x8	700	5350 46x10	800	7550 42x16	800	8950 42x16	800	10425 48x17	800	11925 48x17	800	14900 60x17
112	87	360	2350 24x10	400	3475 32x12	480	5000 36x15	480	6000 36x15	480	7100 42x16	480	8125 42x16	400	8450 43x16
120	87	500	3050 38x8	650	5275 46x10	700	7000 42x16	800	9500 48x17	800	1175 48x17	800	12650 60x17	800	15800 60x17
112	91	300	2025 24x10	400	3650 32x12	420	4575 34x13	420	5500 36x15	420	6500 36x15	420	7425 42x16	390	8625 42x16
120	91	500	3175 38x8	650	5500 46x10	700	7325 42x16	800	9925 48x17	800	11575 48x17	800	13225 60x17	800	16550 60x17
112	95	300	3025 28x12	300	2800 28x12	360	4100 34x13	360	4900 36x15	360	5800 36x15	360	6650 36x15	360	8300 42x16
120	95	500	3325 45x8	650	5750 46x10	700	7650 42x16	800	10350 48x17	800	12100 60x17	800	13800 60x17	800	17250 60x17
112	97	200	1450 20x9	220	2100 24x10	240	2750 28x12	240	3300 28x12	240	3900 32x12	240	4475 34x13	240	5575 36x15
120	97	450	3050 38x8	500	4525 46x10	600	6700 42x16	800	10575 48x17	800	12350 60x17	800	14100 60x17	800	17650 60x17
120	106	400	3050 38x8	450	4575 46x10	500	6100 36x15	700	10100 48x17	700	11800 48x17	700	13500 60x17	700	16850 60x17

rolls. It would seem to be a simple proposition, knowing the proper drafts to take, to arrive at the correct gauge by having the dial read 0.500-in. for a ½-in. plate or 1.00-in. for a 1-in. plate. Unfortunately, this is only true about 5 per cent of the time, particularly on three-high mills and on the older type, wide four-high mills. The other 95 per cent of the time, the screwman is required to make a mental calculation which involves the width and gauge of the plate to estimate the relative effect of the spring in the mill. An example of this type of calculation is given in Figure 1. This calculation is only a rough guide to the screwman as to where he may expect to hit the desired gauge. It will vary

PLATE: 70" WIDE, 1/2" GAUGE
DIAL READING: .500"
Variation
For every 10" over 70" in width subtract .01" from the dial reading
For every 10" below 70" in width add .01" to dial reading
For every 1/16" below 1/2" subtract .01" from dial reading (dial will read .355" for a 70" wide 3/8" gauge plate)
For every 1/16" above 1/2" add .01" to dial reading

Figure 1 — The screwman must make adjustments in the dial setting most of the time to take into account the effect of width and gauge of plate as well as spring of roll.

with the mill which is being operated (width and type, i.e. 3 or 4-high), the condition of the mill (hollow or full) etc. It is also only true for the average finishing temperature, and if the plate is hotter or colder than this average, the screwman must adjust himself accordingly. On the modern type of four-high mill such as our 120-in. mill, it is necessary for the screwman to be guided somewhat by the width and gauge of the plate being rolled as well as the condition of the mill. However, the variation of the actual gauge of the plate as compared to the dial reading is less than on the older mills and the amount of calculation necessary is materially reduced. This permits a faster operation on the part of the screwman, and also results in a more consistant product as far as gauge is concerned. This difference between the newer mill and the older type mill is due primarily to improved bearing design on the roll necks combined with a much stronger screwdown mechanism. Although the ratio of neck diameter to roll diameter has remained fairly constant on all our mills, the necks on the 120-in. mill are longer and the backing roll necks are tapered. This gives more bearing surface. This fact, coupled with oil-film bearings on the backing rolls and roller bearings on the working rolls, has been one of the prime causes for the improved mill operation. The automatic preset screwdown control on the 120-in. mill has done much toward getting improved gauge conditions on our plates and has done much to relieve the screwman of the calculations used on the older mills. This enables him to standardize his practice considerably on plates of the same width and gauge, and results in a higher finishing temperature off the mill and more uniformity in plate gauges.

This problem of gauge is a definite one on a three-high mill, not only across the plate but from end to end. This is due to the lack of strength in the construction compared to a four-high mill. Every effort is made to keep it to a minimum with the result that the length of the rolled plate, particularly in the lighter gauges, is cut down. A number of blank or light drafts are also used to take the spring out of the mill and even up the gauge. The original four-high construction as represented in our 206-in. mill did much to eliminate this problem. The difficulty of locking the middle roll on a three-high mill with a heavy draft was previously mentioned. When the 206-in. mill was designed, the designers were foresighted enough to provide a friction drive on the bottom back-up roll. The purpose of this friction drive was to overcome the inertia of the bottom back-up roll and keep it moving at all times with the work roll, since the only other source of drive for it was the friction caused by the weight of the bottom work roll. However, occasionally it was found that even the friction drive would slip and as a result the roll would lay idle. When this condition happens, it is extremely possible to twist the neck off a roll with little or no draft on the plate. Fortunately it does not happen very often because of careful mill operation. This trouble was eliminated in more modern design by the use of four hydraulic plungers in each top work roll chuck operating off the hydraulic system. These plungers hold the work rolls firmly against the backing rolls, and enable the back-up rolls to be properly driven by friction. The situation is further improved by the bearings on the roll necks.

The variable speed of the four-high mill has been of great assistance in not only increasing production, but it eliminates the objections previously brought out in the discussion of the three-high mill. This results in a higher finishing temperature and a plate with less

Figure 2 — The 206-in. plate mill is the largest in this country. It was recently revamped to use an electric drive.

Figure 3 — The 112-in. mill is a three-high unit which now serves as a rougher for the 120-in. four-high unit.

center (if proper procedures are followed) and a more uniform gauge on the plate from end to end.

Buckles are usually the result of poor screw manipulation by the screwman. It is necessary for him to know at all times the condition of his mill, whether it is full or hollow. A full mill will have a tendency to buckle the plate in the middle, unless the screwman adjusts his drafts in the finishing stages so the rolls will spring enough to have an even bearing across the entire width of the plate. A draft that is not heavy enough would have more bearing on the center of the plate, and would consequently stretch the metal more at this point than on the outer edge. A hollow mill is very difficult to manipulate on wide, light gauge material, since the rolls have too much bearing on the edges, and would stretch the metal too much at these points, resulting in wavy edges. The logical solution is to change the rolls when this problem is encountered. Buckles are encountered on both the three-high and four-high mill. However, the stronger construction of the modern four-high mill has helped materially in this problem.

Heavy center is also a matter of mill condition, mill construction, and drafting procedure. It is a problem encountered particularly with plates under 1 in. gauge. In the lighter gauges the pressure exerted during the finishing process is so great that the rolls spring or bend in the middle according to the width and temperature of the plate. This results in the plate having excess metal in the middle, and "fishtailed" ends. This can be reduced considerably by using light drafts in the finishing stages and keeping the mill full. The question may arise as to why the rolls are not always kept convex so that heavy centers may be eliminated. However, there are a number of factors that must be considered: (1) an extremely full mill is very difficult to control and may result in cobbled plates and slow mill operation; (2) the mill must be prepared to roll long, narrow plates at times which cannot be handled on a full mill; and (3) if too much convexity is put into the rolls, there is a danger of causing the rolls to spall.

The problems of *narrow* and *wide and short* are largely personal errors of the operators.

SUMMARY

In summarizing the foregoing discussion of the direct rolling of plates on the three-high mills and four-high mills at Lukens, the writer pointed out the following *disadvantages of the three-high mill construction:*

1. Those imposed by the small middle roll.
   a. Uneven over-roll.
   b. Uneven and light drafting sometimes necessary.
   c. Source of mechanical difficulty.
2. Those imposed by tilting tables.
   a. Uneven over-roll due to angle of entry of piece.
   b. Source of mechanical difficulty.
   c. Often limit the weight of piece capable of being rolled.
   d. Often limit width of piece that can be rolled due to lack of adjustable sideguards.
3. Constant speed, non-reversing characteristics of mill.
4. High "spring" in mill due to light construction, older-bearing design, etc.
5. Limitations on maximum length and width of plates imposed by mill design.
6. Lower yield.
7. Lower finishing temperatures makes it more difficult to get a good quality surface.

The following *advantages of the four-high mill construction* have been given as:

1. Use of two working rolls of equal diameter, each backed with a backing roll gives a much stronger construction.
   a. Reduces spring in mill and center in plate.

Figure 4 — The 120-in. mill is driven by a 7000 hp, d-c reversing motor.

b. Gives a more even over-roll condition on plate.
c. Permits heavier drafting when desirable.

2. Permits use of stationary tables.
   a. Eliminates the objections to tilting tables.
   b. Permits use of adjustable sideguards.
3. Modern bearing arrangement of later mills.
   a. Further improves gauges on plates.
4. Higher finishing temperature, permits use of more descaling water at higher pressures with a further improvement on plate surface and general plate quality.
5. Variable speed of the four-high mill permits the proper adjustment of speed with draft to obtain a good quality plate in a minimum time.
6. Higher yield of prime plate.
7. Heavier ingots are capable of being rolled at a more satisfactory production rate.

The comparison of three-high and four-high mills has been made with the mills and the direct rolling practice of Lukens in mind.

In rolling ingots direct to plate it is essential that the ingot design be suitable for the production of quality ingots and for rolling on a mill at a reasonable production rate with good quality plates resulting at a high yield. Wherever possible, the ratio of ingot thickness to finished plate thickness is held close to 12 to 1, and the ratio of ingot width to ingot thickness is held as high as practical within the limitations of good practice. This ratio varies from 2 to 1 to 5 to 1, increasing normally with decreasing ingot weight.

In conclusion, it is the opinion of the writer that the three-high plate mill imposes quite severe restrictions on the operators trying to make quality plates at a high production rate. The modern four-high mill has eliminated a great number of the handicaps imposed by the three-high design and has done much to improve the quality of our present day steel plate.

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DISCUSSION

PRESENTED BY

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ELMER LYNCH, Superintendent Sheet and Plate Mills, Sheffield Steel Corp., Houston, Texas.

FRED WALDORF, Pittsburgh, Pa.

A. E. Eck: When you installed the four-high mill on the 112-120-in. mills, how much did you increase the production; could you tell me that?

Robert C. McMichael: I would say possibly two-thirds or 75 per cent.

C. E. Pritchard: As pointed out by Mr. McMichael, there are two different methods of approach to the subject at hand. He referred in his paper to preference for direct rolling of slab ingots, where in our particular case we tend to lean toward the rolling of slabs.

The method adopted in our case is that of rolling the plates from slabs previously reduced from an ingot on our slabbing and blooming mill, and then conditioned for subsequent heating and rolling to the desired size on a two-stand, three-high, 84-in. plate mill.

The major steel consumer in our distribution of product is the 30-in. hot strip mill, with the 84-in. plate mill in an intermediate role, and forging steel production in the form of blooms and billets for outside customers maintaining a lesser position.

Due to the availability of a slabbing mill, it has been found to be more expedient to avail ourselves of the many benefits to be derived therefrom in regard to both steel provision and quality of end product for the orders processed through our various operations.

Although we are currently employing four slab ingot sizes in our plate mill provision, it is our intention to delete them entirely in favor of a suitable slab section. The recent installation of a larger slabbing mill makes it possible to provide suitable edge working of the desired slab section heretofore unobtainable on the retired mill housings. A higher yield of prime plate is anticipated in our conversion from slab ingots to slabs. Tests conducted on typical rolling schedules have confirmed the merits of this change under our normal operating conditions.

The slab ingots, namely 12 x 26, 12 x 30, 12 x 34, and 12 x 40 in., had been supplemented in prior years with two additional sizes, 9 x 20, and 10 x 24 in. The latter two sizes were discontinued due to their tendency to develop cracks in the rolling cycle, and wash on the surface during the heating cycle in the smaller furnaces. In most cases, bottom casting has been employed for the slab ingots.

Heating of both the slab ingots and slabs is presently provided by four small, and two large side door furnaces. Bunker "C" fuel oil has been utilized exclusively for all six furnaces. Some modification to this heating practice to include coke gas as an auxiliary fuel is contemplated in conjunction with a future furnace program.

For purposes of comparison, it might be stated that during the year 1952 our 84-in. plate mill rolled an average ingot weight of 2674 lb, whereas the average per slab was 1294 lb, or an over all average piece weight of 1984 lb. These figures include a minimum range of weights for slabs of 380 lb on the low side, and a maximum for slab ingots of approximately 5000 lb, on the high side.

It might be pointed out at this time that a variety of products are produced currently on our 84-in. plate mill, which includes a gauge range from $\frac{3}{16}$ to $\frac{3}{4}$ in. for plain plate: approximately $\frac{1}{8}$ in. (6.15 lb) to $\frac{3}{4}$ in. for pattern floor plate, and $\frac{1}{8}$ to $\frac{1}{2}$ in. for an abrasive non-skid type floor plate, the latter being rolled double thickness in the form of a sandwich.

The uneven over-roll condition noted on the Lukens three-high mills has not proven to be other than a negligible factor in our operations, presumably due to the difference in draft schedule and provision employed.

Special emphasis has been placed on the finishing temperatures of our operations, as the extremely severe rolling demands imposed by pattern floor plate make same imperative. Our draft schedule, as such, must be maintained in keeping with this physical requirement, and undoubtedly has made possible our ability to produce a satisfactory blue light gauge plate while limiting somewhat the length of the plate produced. Acceptable gauge compliance has necessitated keeping the rolls in a "full" mill condition, especially on the finishing stand.

Future plans call for adjustable side guides complete with descaling spray nozzles being installed on the tilting tables, the hydraulic water pressure to be 1200 psi. This practice has been found to be adequate on similar mill installations, and should offer an increased flexibility to our present operations. Usage of a fluted middle roll in the roughing mill to break the scale surface of the slab will be continued in the future mill rolling practice.

Robert A. McClure: I think that Mr. McMichael has presented an interesting picture here of the plate mill history and development at Lukens Steel, and a good analysis of the advantages and disadvantages of the three-high and four-high plate mills.

At Homestead, our practice is to use what we call the slab-ingot to slab on the primary mill to intermediate slab form, then put the slab into the finishing mills for rolling into finished product. In regard to the three-high and four-high mills, our experience has been about the same as that indicated by Mr. McMichael. We started with the original of all four-high mills back in 1888, when we put in a 32-in., four-high armor plate mill. We rolled some armor plate on this four-high mill, then immediately converted it into a slabbing mill and have been using it as such ever since. We are not using it at the present time, but we can if necessary.

At the same time, we started out with a three-high, 119-in. mill; then we went through the 74, 84, 110 and 140-in. on three-high mills up to our present setup, where we have four-high mills only on our two sheared plate mills.

At the present time, we are operating a 45-in. slabbing mill, a 100-in. four-high, semi-continuous sheared plate mill, and a 160-in. four-high sheared plate mill, and a 48-in. two-high universal mill. In making the changes in mill design and size, through this period which Mr. McMichael has referred to, the changes that were made in the mills and in the practices were primarily due to those limitations which Mr. McMichael has pointed out. We, at Homestead, feel that the four-high has definite advantages over the three-high, and we feel that for us, rolling from ingot to slab and slab to plate also has definite advantages.

Homestead has considered direct rolling from time to time; in fact, we have had several experimental rollings. However, we have never pursued the project or developed the practice due mainly to quality considerations.

From the open hearth point of view, there were quite a number of problems involved in view of the size of the shops, the number of shops, types of steel produced, and the amount of tonnage involved. It has always been considered non-economical and practically impossible to go to a bottom pouring practice, which is apparently necessary if you are going to follow a practice of direct rolling from slab to finish plate. For example, open hearth No. 5, which is our primary source of steel for the plate mills, consists of eleven furnaces with a capacity of 225 tons each, with a daily output of some 6500 tons. It can readily be seen that bottom pouring facilities in this shop would require rather a fantastic layout.

Considering Lukens' direct rolling practices, as outlined by Mr. McMichael, there are several questions which come to mind. At Homestead, where we are rolling from ingot to slab, and slab to finished product, intermediate conditioning is one of our major problems. Mr. McMichael has mentioned that ingots are inspected and conditioned, if necessary, prior to charging at Lukens. I would like to ask Mr. McMichael to what extent this conditioning is necessary, and I would like to ask if and to what extent they condition in the intermediate stage while rolling? In other words, in the case of a partially rolled ingot or plate, do they take it off the table, condition it, and reheat it, put it back into the mill and roll it down to size. If so, I would be interested in learning what facilities they use for reheating, what limitations they place on the size of the piece handled, and how the operation is performed.

Robert C. McMichael: I mentioned that we have increased the ratio of width to thickness on our ingots, particularly on the lighter ingots. That change was made with the desire to increase our production on the mill and we found, as Mr. Pritchard has found, on our thinner molds and slabs, the uneven over-roll caused by the three-high mill is materially reduced as the thickness of the ingot is reduced. In other words, if you are rolling 9-in. thick ingots, the uneven over-roll is not pronounced enough to worry about. The uneven over-roll presents a serious problem when rolling ingots 15 in. thick or greater.

Now, in reference to the conditioning of the ingots prior to rolling, we make a standard practice of removing any open hearth fins from the bottom of the ingot. Where we are rolling hot top steel to light gauge plates, we remove the hot top and in all cases make sure that any collars are removed in order to prevent damaging the mill. Each heat is rim tested by groups in order to make sure the open hearth has given us a good skin on the ingot, and if we find any heats that have a thin skin condition, we have to treat them specially in the mill by an additional breakdown operation and recharging.

It is a foregone conclusion that the open hearth has to be good, and our open hearth department is. I feel I cannot give them too much praise because they do a very nice job. We have to get high quality ingots in order to make the direct rolling practice work. Our rejections are such that we feel our practice is right from that angle. Regarding the conditioning of breakdowns —occasionally, you will expect an ingot in the mill to be given three or four passes and then show a defect such as a splash, snake, butt crack, etc. When that occurs, we do not attempt to condition the ingot on the mill tables. It is set off with the cranes that are available and transferred from the mill to the yard where it is inspected and conditioned with a regular scarfing torch. After it has been ascertained that the quality of the breakdown will permit the rolling of a good plate, it is charged either in our pits or in our side furnaces.

The only limitations to the re-rolling of these slabs satisfactorily is the amount of conditioning necessary to remove the defect, and the ratio of reduction between the slab and final plate.

Fortunately, the number of ingots requiring slabbing because of defects is remarkably low.

Robert A. McClure: I would mention something here in regard to ingot sizes and slab sizes. On our 45-in. mill we cover a range which on our smallest ingot is 16 to 54 that runs a little better than 10,000 lb and then we go to 75,000 lb. The average ingot weight on the mill will average out around 34 or 35,000 lb. The average now is 12 to 25,000.

Going into the plate mills, we have slabs going into 160-in. mills ranging from 2500 lb at a minimum to one order which we are making at the present time that takes a 60,000-lb. We think that with the ability to take the variety of ingot sizes in the slab mill and then of the intermediate, we have greater flexibility on our plate mills and our open hearth end, too, than we would have under a direct rolling setup.

In other words, right now I cannot imagine anything more inflexible than to have our mills tied up directly to our open hearth.

Elmer Lynch: We have a very similar setup at Lukens with 116-in., three-high breakdown mill, and 130-in., four-high reversing finishing mill.

The question I would like to ask Mr. McMichael is on end-to-end variations. When you roll the ingot, do you find the variations greater than when you slab that ingot and reroll it, that is, is there any difference in your end-to-end variations?

Robert C. McMichael: I would say not. The largest ingot that we handle on our mills now is on the 206-in. mill which is 108 in. wide by 40 in. thick, and we can pour into that mold 132,000 lb under the hot top.

F. Waldorf: How thick an ingot do you roll out?

Robert C. McMichael: 40-in.

F. Waldorf: How many passes do you give it?

Robert C. McMichael: I would guess that we would take a number of passes on an ingot like that. Those ingots will roll down to a place normally about 6½-in. thick. Let us put it this way, we limit the mill to 12 per cent reduction per pass, and no more than half an inch.

F. Waldorf: Do you vary much from that?

Robert C. McMichael: I am speaking of the rolling of this big ingot on the 206-in. I do not take my statement as being standard practice on every mill. We limit it to about 12 per cent reduction or a maximum of half-inch drafts.

F. Waldorf: How long does it take to roll down your large ingot?

Robert C. McMichael: On this particular plate that we are discussing, it takes approximately 20 or 25 minutes, with a 108 by 40-in. down to 6½ in. thick ingot with our present drive.

F. Waldorf: With your earlier drive, I understand that the mill merely nibbled away on the ingot.

Robert C. McMichael: The steam engine drive was entirely different from the electric drive that we have now. It is a terrific improvement. It is like another mill, really. We have better speed controls and better control of the mill all the way through.

F. Waldorf: I once took part in a discussion of a four-high, 36 and 54 x 220-in. plate mill which was under consideration for rolling down 48 x 108 x 144-in., 198,-000 lb, armor plate ingots to 196-in. wide plate, 24 and 13 in. thick in two heatings; and also 32 x 66 x 90 in., 54,000-lb ingots to 196 in. wide 1⅝ in. plate after only one heating.

Even with many passes of 1¾ in. draft, which represents slightly less than 18 degree bites, it showed that 25 passes would be required to bring the 48 in. down to 24⅛ in. if sufficient motor power was available; and after this reheats, with ⅞ and ¾ in. drafts in the majority of the passes, it would require 18 more passes to bring the 24⅛ in. down to 13 in.

For the smaller ingot with 1¾ in. drafts at the start, and gradually decreasing them, 45 passes appeared to be required to bring the thickness down from 32 to 1⅝ in.

While pondering this rolling, it was pointed out that Lukens places an ingot on the table and allows the mill to whittle away at it for an hour or more. We therefore reviewed the rolling of the 32-in. ingot by starting out with drafts of ¾ in. and by gradually decreasing them, we found that the full schedule would require 62 passes.

No attempts were made at time studies for the smaller ingot, but studies on the 48-in. ingot indicated that, if the motors could furnish the power, it could be brought down to 24½ in. in 25 minutes, and after the reheat, 20 minutes more would be required to bring it down to 13 in.

When it came to estimating torque requirements for all of the passes mentioned above, we were confronted with the job of finding a power curve which could be

TABLE IV

Place	Mill	Ingot	Motor torque
France	39 and 55 x 185 in. 4-high	72-ton, 112 passes	1626 ft tons at 30 rpm
Germany	39 and 63 x 196 in. 4-high	100-ton	1554 ft ton at 53.6 rpm
Germany	41 and 63 x 196 in. 4-high	100-ton	1950 ft ton
Japan	43 and 63 x 205 in. 4-high	165-ton	1600 ft ton at 60 rpm
Japan	43 and 63 x 204 in. 4-high	Armour plate	2305 ft ton at 30 rpm

used on a 48-in. thick ingot. There were two curves for rolling out 30 and 32-in. ingots which agreed quite closely. They were for mills equipped with plain bearings and, since our mill was to be built with oil-flooded plain bearings, we felt that by making allowance for the lower friction, with these bearings, power values from these curves could be stretched out somewhat and so might be used for 36 or possible 38-in. ingots, but it was doubted that they would answer for 48-in. ingots which would be 10 to 12 in. thicker.

We had an old power curve which was once worked up for use on blooming mills having plain bearings, and this showed power values about 30 per cent higher than those called for by the two curves just mentioned. By carefully estimating the friction factors for plain and oil-flooded bearings, we found that the mongrel curve, if corrected downward by about 30 per cent, would closely follow the trend of the two other curves.

We were encouraged to believe that the two plain bearing curves could be tried out for estimating the torques for the 48-in. ingot if oil-flooded bearings were used, but found that 5000-hp motors on the work rolls would have to develop every ingot torque for the majority of the passes. It appeared that the two would just get by for the 32-in. ingots, albeit armor plate requires about 50 per cent more power than does low carbon steel. No one seemed to consider that we would dare go to 6000-hp motors.

We also found that about half the passes in the 45-pass schedules for the 32 to 1⅝ in. rolling would show rolling pressures of around 6,000,000 lb, but that the later passes would show pressures over 9,000,000 lb, and one pass even went as high as 10,700,000 lb.

The largest oil-flooded bearing for which we had any rating showed a capacity of 5,250,000 lb which would correspond to a loading of 100 per cent during the heaviest pass.

For the 62-pass schedule on this ingot, the highest pressures would hover around 7,500,000 lb, thereby imposing a loading of around 70 per cent if a siege of cold steel was never visited upon the mill at any time.

At this juncture, I made the statement that we could not roll down a 48-in. ingot in the mill we were considering. I pointed out that while we could nibble at the top and bottom surfaces, we could not develop pressure enough to work on the middle of the ingot; that the top and bottom faces would be stretched out until the ends were fish-tailed, until they turned inward and assumed the shape of the moon in her first and last quarters, but it would be a long time until the middle of the ingot was stretched out enough to permit of burning out an 180-in. length of stock which was a requirement of the projects.

I produced a clipping from the May 1937 Iron & Steel Engineer showing a photograph of the Lukens mill rolling an ingot into a slab which was to be used for making a large fly wheel. This photograph clearly showed how the fish-tailing grows, and the ends turn inward but still extend far out beyond the length of the stock at its mid-point.

It occurred to me that we were analyzing a mill that would be too small for its job.

Since then my belief has been somewhat borne out by the appearance of two articles in the Blast Furnace and Steel Plant of April and May of 1943 in which several foreign mills were described in Table IV.

While our mill was never built, the research work was well worth while in that it gave us a glimpse at the trend in mill requirements as time goes on. When the limit will be reached no one can foresee.

There is a demand for copies of the following Yearly Proceedings:

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AISE

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AUSPICES OF
ROLLING MILL COMMITTEE

BELLEVUE - STRATFORD HOTEL

PHILADELPHIA, PA.

MAY 3, 4, 5, 1954

Monday, May 3, 1954

9:00 am — Registration — 18th Floor

9:30 am — COMBUSTION SESSION — South Garden

Chairmen: George J. Gockstetter, District Combustion Engineer, Republic Steel Corp., Chicago, Ill.

F. R. Pullen, Fuel Engineer, Bethlehem Steel Co., Johnstown, Pa.

"The Fairless Soaking Pits," by C. R. Wilt, Special Engineer, Loftus Engineering Corp., Pittsburgh, Pa.

"Maintenance of Slag Bottom Soaking Pits," by John A. Warchol, Supervisor, General Labor, Lukens Steel Co., Coatesville, Pa.

9:30 am — ROLLING MILL SESSION — Rose Garden

Chairmen: Louis Moses, Mill Engineer, Bethlehem Steel Co., Bethlehem, Pa. R. C. Schaefer, Superintendent Hot Strip Mill, Wheeling Steel Corp., Steubenville, Ohio.

"Increased Rod Production by Conversion of a Two-Strand Rod Mill to Three-Strand Operation," by C. H. Burden, Chief Project Engineer, and W. E. Zelly, Divisional Plant Engineer, John A. Roebling's Sons Corp., Trenton, N. J.

"Modernization of Rod Mill at Steel Co. of Canada," by D. W. McLean, Assistant Superintendent of Rod and Bar Mill, The Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada.

2:00 pm — MECHANICAL AND LUBRICATION SESSION — South Garden

Charmen: C. R. Hand, Assistant Superintendent, Mechanical Dept., Bethlehem Steel Co., Sparrows Point, Md.

E. C. Hite, Assistant Superintendent of Maintenance, Steel and Tube Div., Timken Roller Bearing Co., Canton, Ohio.

"Screwdown Lubrication," by William A. Holt, Eastern District, Brooks Oil Co., Philadelphia, Pa.

"The Application of Lubricants to Rolling Mills — Problems, Developments and Trends," by Wayne G. Ritter, Trabon Engineering Corp., Pittsburgh, Pa.

"Water Processing at Fairless Works," by H. S. Spitz, Chief Engineer United States Steel Corp., Fairless Hills, Pa.

2:00 pm — ROLLING MILL SESSION — Rose Garden

Chairmen: A. Krause, General Superintendent, Rolling Mill, Steel Div., Ford Motor Co., Dearborn, Mich.

Alex Montgomery, Jr., Assistant to Vice President — Rolling, United States Steel Corp., Pittsburgh, Pa.

"Rolling of Shapes in Alloy and Tool Steel Grades," by Ernest E. Davis, Superintendent Hot Mills, and Albert A. Highley, Assistant Superintendent Hot Mills and Roll Designer, The Carpenter Steel Co., Reading, Pa.

"Roll Knurling at South Works, United States Steel Corp.," by E. M. Benedict, Superintendent, Roll Shop, South Works, United States Steel Corp., Chicago, Ill.

"Modern Manufacture and Use of Cast Rolling Mill Rolls," by Dr. F. H. Allison, Jr., Vice President and C. E. Peterson, Sales and Research Metallurgist, Rolls Division, Blaw-Knox Co., Pittsburgh, Pa.

Tuesday, May 4, 1954

9:00 am — ELECTRICAL SESSION — South Garden

Chairmen: K. L. Johannsen, Division Superintendent, Maintenance and Utilities, United States Steel Corp., Fairless Hills, Pa.
R. T. Lucas, Electrical Superintendent, Weirton Steel Co., Weirton W. Va.

"Operating Characteristics of Tandem Mill Drives," by R. G. Readle, Steel Mill Engineering, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

"Electrical Power Distribution and Utilization at Lone Star Steel Co.," by R. G. Orthwein, Chief Electrical Engineer, A. J. Boynton and Co., Chicago, Ill.

"Unique Electrical Features of the Fairless Universal Slabbing Mill and Hot Strip Mill Finishing Train," by Warren Reid, Steel Mill Engineer, and R. H. Wright, Steel Mill Engineer, Metal Working Section, Westinghouse Electric Corp., East Pittsburgh, Pa.

9:00 am — ROLLING MILL SESSION — Rose Garden

Chairmen: C. S. Lambert, Superintendent Merchant Mills, Campbell Works Youngstown Sheet and Tube Co., Youngstown, Ohio.

C. E. Pritchard, Superintendent of Mills, Alan Wood Steel Co., Conshohocken, Pa.

"Performance Factors Affecting Bar Mill Cooling Bed Arrangement," by E. C. Peterson, Engineer, Birdsboro Steel Foundry and Machine Co., Birdsboro, Pa.

"Plate Mill Design and Rolling Practice," by Elmer Lynch, Superintendent Plate Mills and Tank Head Dept., Sheffield Steel Corp., Houston, Texas.

"Cold Reduction Facilities at Fairless Works," by Robert R. Shedd, Design Engineer, Fairless Works, United States Steel Corp., Fairless Hills, Pa.

2:00 pm — FAIRLESS SESSION — Rose Garden

Chairmen: J. N. Imel, Superintendent Sheet and Strip Dept., Jones and Laughlin Steel Corp., Pittsburgh, Pa.

Leonard Larson, Chief Engineer, Republic Steel Corp., Cleveland, Ohio.

"Iron From Cerro Bolivar," Talk and Movie by John L. Young, Vice President — Engineering, United States Steel Corp., Pittsburgh, Pa.

"Engineering Conception of Fairless Works," by J. D. Rollins, Assistant Vice President — Engineering, United States Steel Corp., Pittsburgh, Pa.

"Modern Continuous Weld Pipe Mill," by L. V. Johnson, Chief Engineer, National Tube Div., United States Steel Corp., Pittsburgh, Pa.

7:00 pm — INFORMAL STAG DINNER — Ball Room

Speaker: M. W. Reed, Executive Vice President — Engineering and Raw Materials, United States Steel Corp., Pittsburgh, Pa.

Wednesday, May 5, 1954

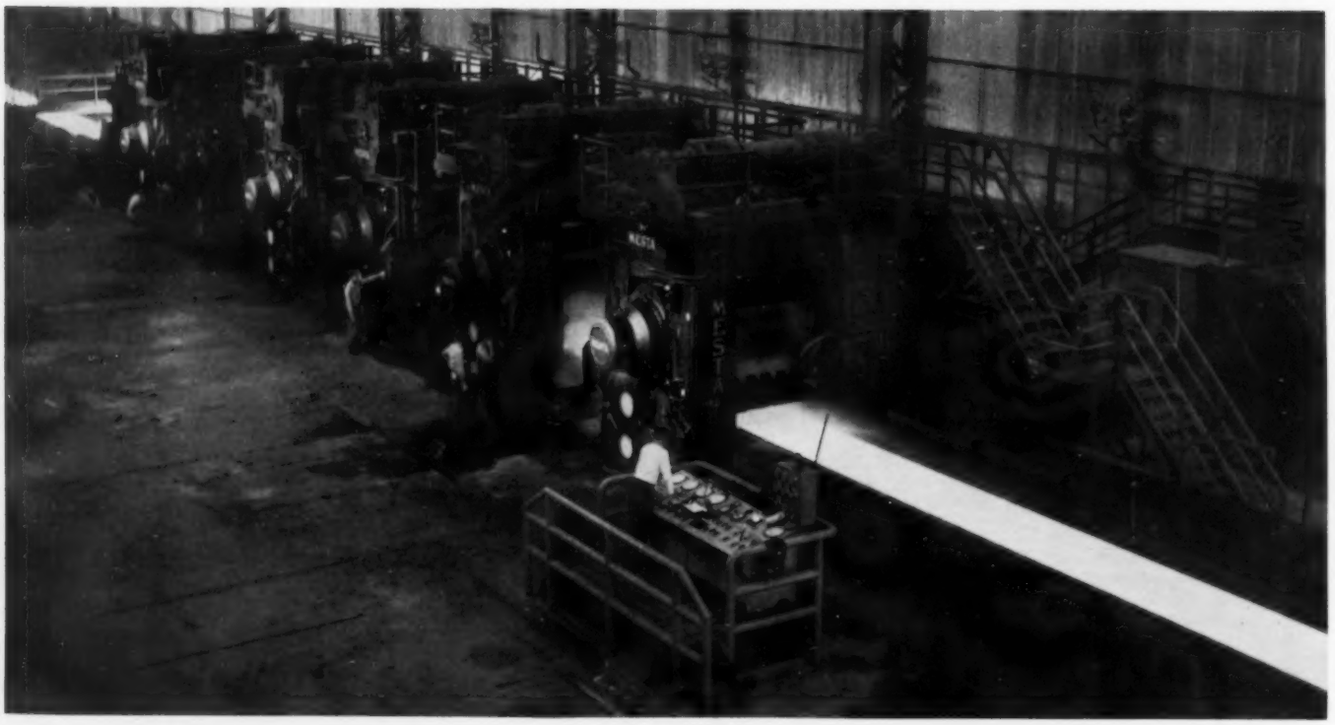
8:30 am — INSPECTION TRIP —

Fairless Works of United States Steel Corp., Fairless Hills, Pa. Buses leave from Bellevue-Stratford Hotel.

HOTEL RESERVATIONS

For hotel reservations, write directly to the Bellevue-Stratford Hotel, Philadelphia 2, Pa., giving time of arrival, type of accommodations desired, and period of stay. Reservations should also state that they are for the 1954 AISE Spring Conference.

The inspection trip on Wednesday, May 5th will give members of the AISE an opportunity to see some of the latest and most modern steel plant equipment. The new hot strip mill shown below was designed for high tonnage production.



CONTROL OF ELECTRIC POWER SYSTEMS IN STEEL PLANTS

By K. S. KUKA
Superintendent
Electrical Engineering and Construction
Tata Iron and Steel Co., Ltd.
Jamshedpur, India

. . . . a flexible and stable electric distribution system is the nerve center of a modern steel plant . . . .

▲ CHARACTERISTICS of steel mill electric power loads have peculiarities in the fact that large blocks of power are concentrated in few locations, such as steel mill motor houses, while the intermittent nature of metal rolling imposes heavy load swings at frequent intervals.

Figure 1 gives a typical load curve of an integrated steel plant with a 15-minute demand of about 55,000 kw.

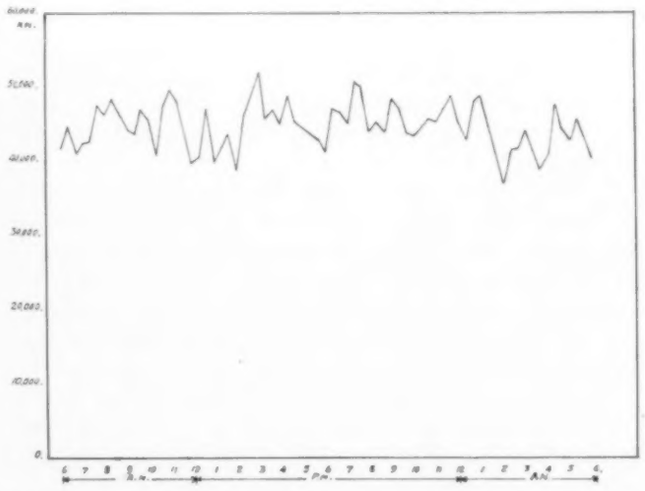


Figure 1 — This 24-hr load chart shows the variation in the power demand of an integrated steel plant.

Steel mill power distribution systems have thus of necessity to be of large capacity with major sub-stations in relatively few locations, and stiff enough to carry heavy swings without undue voltage variation. Reliability of service, good voltage regulation, alternative sources of power feeds, flexibility of control, safety to equipment and to operating personnel, have all to be incorporated without making the system unduly costly and within the finances allocated.

Table I illustrates the load conditions of an integrated steel plant supplying all its many services, during the last week of an operating month. It will be observed that the momentary peak loads on Monday appear due to the starting of some of the rolling mills after Sunday maintenance shut-downs. Friday appears as the highest load day of the week, because of the all-round efforts at meeting the target production.

CONTROL OF PLANT MAXIMUM DEMAND

Where steel plants have their own power generating facilities and if the installed generating plant is capable of sustaining the plant demand as it comes, the problem of power demand charges is eased, because the money is already invested and any additional production is a net gain to the company.

However, when the electric power is purchased from an outside utility power company, it would demand some consideration to see if any small extra production is not being obtained at a high cost in terms of electric power bills.

It can be observed from Table I that Friday appears to be the day of maximum production with the day's average load at 45,800 kw and maximum demand of 56,300 kw. The loads on Tuesday to Thursday, the three days of almost consistent production, average about 44,127 kw with the maximum demand at 53,000 kw. Taking an overall power consumption, averaged over the entire plant operations, of about 380 kwhr per ton of finished steel production, the additional tonnage

TABLE I

Total Power Generation Over a Week of an Integrated Steel Plant

	Monday	Tuesday	Wednesday	Thursday	Friday
1. Day's average load in kw	42,350	44,500	43,960	43,922	45,800
2. Shift maximum average load in kw	45,270	46,800	46,770	45,765	49,800
3. Maximum sustained 15-minute load in kw	50,580	53,100	52,520	52,140	56,300
4. Momentary peak-load in kw	66,340	60,340	56,340	59,760	59,960
5. Day's average load factor, per cent	84.0	82.0	84.0	84.0	82.5
6. Ratio of momentary peak to sustained demand	1.30	1.13	1.07	1.14	1.07
7. Ratio of sustained demand to shift maximum average	1.12	1.13	1.125	1.14	1.13
8. Ratio of shift maximum average to day's average	1.07	1.05	1.07	1.04	1.08

on Friday over the average of the preceding three days can be assumed to be about 105 tons, which is produced by raising the power maximum demand by 3,200 kw, i.e. about 3,900 kva with an average power factor of 0.83.

If the utility rates for the extra supply are assumed to be $1.5 per kva of maximum demand and 0.5¢ per unit of consumption, the additional electricity bill, because of 3,900 kva of increased demand charge, thus comes to about $5,850. The additional 105 tons of finished steel on Friday are therefore produced at an additional cost per ton of about $55. It can therefore easily be appreciated how dearly such additional production can be obtained if the plants are permitted to operate in a "Go as you please" manner. If individual mill operations are further scrutinized, it will be observed that the mills such as sheet mills and merchant mills, are the likely sources of the high peak demands if the rolling schedules are so arranged that heavy rolling periods synchronize during a few hours on a month-ending week-day. If the power bill due to the higher maximum demand is charged proportionately to the additional tonnages produced in those mills alone, the cost of production of the small extra tonnage will appear to be prohibitive.

Production men must realize how costly the attempts at breaking short period production records, or month-ending casual attempts at approaching target production can be in terms of electric power bills when distributed on the small additional tonnage produced.

Most steel mills generate part of their electric power from by-product fuels which are always available in the process of steel making. It would therefore pay handsomely, if steel mill generating plant is operated in parallel with the utility system and short time peak loads are carried on works generating plant, while drawing a steady load from the utility system.

EMERGENCY CONTROL OF SYSTEM LOADS

Continuity of power is an essentiality in a steel plant, as sudden power failures are likely to cause costly operating delays and possible danger to furnaces and machines. A few minutes power failure causes comparatively longer delays in re-starting of mills due to cobbles in continuous mills, or heat troubles in other mills, or air pressure failure in bessemer converters.

Utility companies have developed a method of emergency control of system loads by proportionate reduction in system voltage, combined with frequency reduction. Experiments have shown that a reduction in voltage of 3 per cent below normal and a simultaneous frequency reduction of 1 per cent effects a 1.78 per cent reduction in load.

It would be advantageous to try similar methods in steel plants where all the power requirements are generated in their own power houses, and where the developments are such that the generating capacity falls slightly short of the maximum demands on occasions. Such occasions generally appear during the month-ending week when all-round attempts are made to approach the monthly production targets.

However, during emergencies such as the failure of a main generating or receiving unit, the problem of control of power demands rapid shedding of loads, if a total failure is to be prevented due to overloading of the remaining units in service. Such emergencies do occur occasionally and an automatic system which can shed certain loads in such emergencies is of great advantage.

In steel plants, such an emergency load control system should have the following features:

1. It should be simple as well as selective, capable of being incorporated into the system at any time without necessitating any shut-downs, disconnections or readjustment of the main distribution system.
2. Load control signals shall be alarm as well as disconnection. Alarm shall reach all important motor houses and attended substations, where emergency signals are automatically transmitted.
3. The disconnection signals shall be so arranged that they are operative only on the mills to force them to stop rolling. For reversing mills, the flywheel sets are not tripped but the mill motor control is made ineffective so that the mill can be restarted immediately without the necessity of restarting heavy sets with consequent high starting kicks on the power system.
4. Automatic disconnection signals should preferably be provided with inverse time delay, depending on the emergency overload capacity of the power plant.

A simple system of "Emergency Load Control of Power Houses" has been described in a paper by the author published in Iron and Steel Engineer, September 1947 issue, pages 82-85.

CONTINUITY OF POWER SUPPLY — FIRM POWER CAPACITY

The extent to which full continuity of power supply can be insured at each major load center is mainly an economical problem of providing a certain per cent firm power capacity. By firm power capacity is meant that the capacity of the plant in service is such that if the largest unit suddenly trips out, the remaining units can carry the peak loads of the system without overloading. This does not take into account the reserve stand-by plant required for normal maintenance and emergencies. The costs of providing such firm capacity can be justified on the importance of the loads and other alternative possibilities. Few plants can afford to provide such firm capacity at every stage and certain justifiable risks are generally taken, provided spare loose plants are available for replacement.

An economical layout is to provide major load area substations located at suitable load centers, and provide inter-connections so that power in emergency can be transferred from one area to the other, if the stations are not too far situated from one another for the loads to be transmitted. This, of course, takes into account that two major feeders are not down simultaneously, a reasonable assumption to be made.

In case of total power generation or total bulk supply purchase from an outside utility system, it is essential that firm capacity is always available. It is the common experience that it will always pay to provide full firm total power capacity, as unforeseen long outages creating a total power deficit would affect the whole operation very adversely.

In Figure 2 is shown a plan of the main primary distribution system in an integrated steel plant designed to obtain reasonable continuity of power flow at a reasonable capital investment. Table II gives the corresponding load details as well as the interrupting ratings of switchgear at each station bus. The plant started as a self-contained unit, increasing its own generating capacity for a maximum demand of 55,000 kw. As the demand increased further, it was possible to purchase power from a utility company which could transmit power from a distance of about 100 miles.

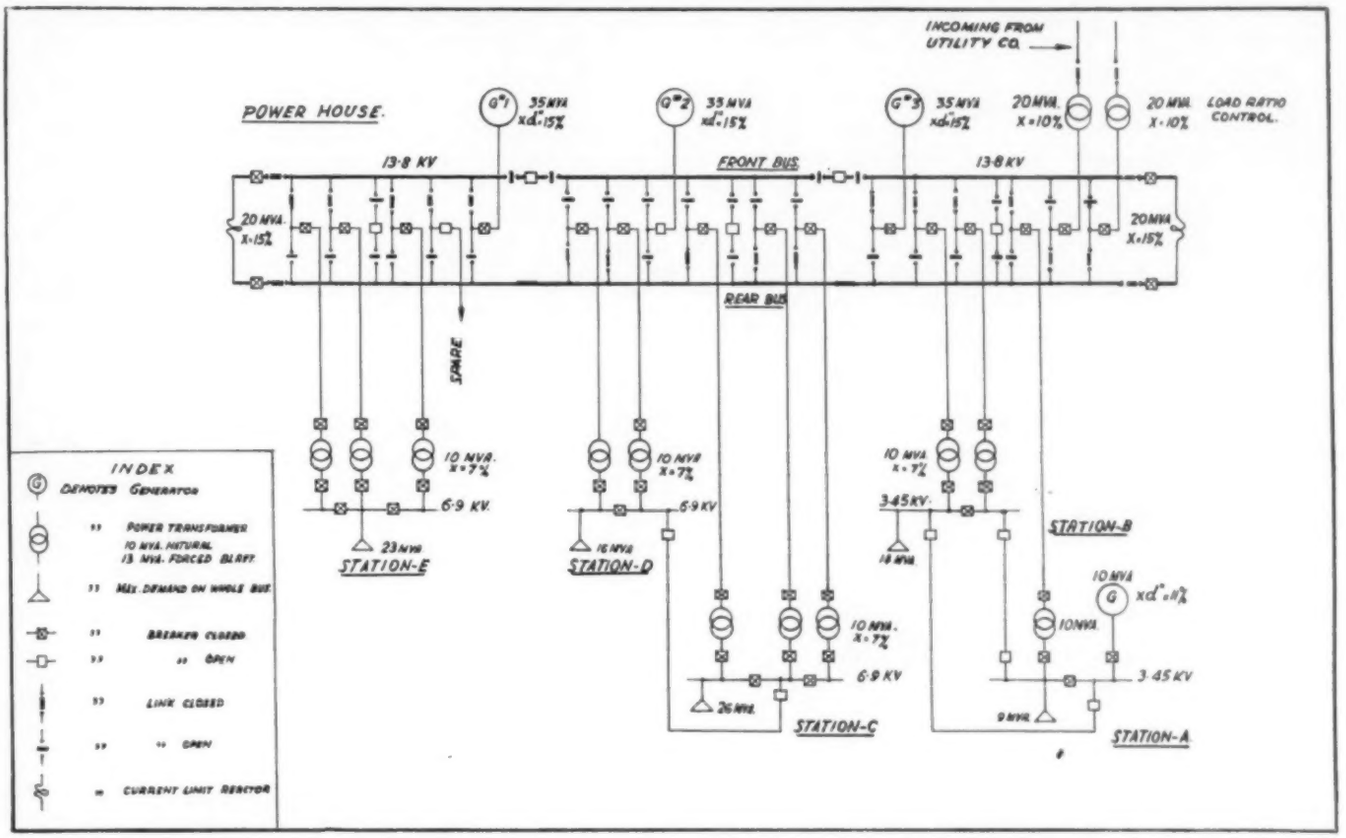


Figure 2 — Layout shows load stations and connections for a primary steel mill distribution system.

Station "A" is in the blast furnace and coke ovens area. A 10,000 kw turbo-set is retained there to utilize surplus steam and blast furnace gases. In every steel plant, steam in quantities is always essential for blast furnace turbo-blowers and coke ovens. As surplus steam and gases are generally available, these can be used for generation of cheap power, and a turbo-generator set is a good and economical solution.

Station "B" is in the area where service shops, such as foundries, machine shops, structural shops and service water pump houses are situated. The two stations are at a distance of about 800 yards and can therefore be conveniently tied together.

The individual motor loads in the area A and B are such that the biggest motors are below 2000 hp. The most economical voltage for motors between 200-2000 hp is 3000 volts. A 3450-volt system is, therefore, adopted in that part of the plants. The maximum demand of the areas A and B is 23,000 kva. Table II shows that the power capacity in these areas is normally based on firm capacity.

Substations "C" and "E" are similarly laid out on

the basis of firm capacity. These stations supply power to the various rolling mills with a peak load of about 49,000 kva. Substation "D" serves the area of steel-melting shops where electrical blowers are operating to supply air-blast to the converters. The duplex process of steel melting is predominant, which accounts for a maximum demand of 16,000 kva. Station "D" has a shortage of about 3000 kva in firm capacity, if the tie between "C" and D" is kept off, which is a reasonable limitation as the loads can be easily controlled in an emergency.

Adoption of load area block stations permits a balanced system of power supply, where the power transformers can be standardized on 10/13,000 kva rating. From the point of view of transport and handling, 3-phase, 10,000 kva self-cooled, oil filled transformers appear to be an optium size which can be conveniently handled in steel plants. Some 30 per cent additional power can be made available by forced blast.

The plant under discussion has a maximum firm steam generating capacity of about 50,000 kw in main power house and about 7,000 kw in Station "A". When the generator in Station "A" is down for overhaul, and if one generator in the power house were to go down, Table II shows a shortage of about 5,000 kva of firm power. This can be easily controlled either by the emergency voltage control, or by shedding the loads with emergency load control system as already discussed. Average power factor of the system is taken at 0.85.

CONTROL OF POWER IMPORT FROM THE UTILITY SYSTEM

Many steel plants generating their own power, in course of expansions are faced with the alternatives of expanding their power houses or purchasing power from an outside power utility company, if such facility becomes available at the time. Under such circumstances, it is necessary to weigh the various conditions carefully before a final decision is arrived at. The main function of a steel company is to manufacture steel products, and if the available finance is used mostly for expansion of steel producing plants rather than in power plant expansion, a much better return on investment is available.

The following major factors have to be considered:

1. Firm generating capacity compared to plant maximum demands already available at the time.
2. Cost of generation with the existing plant as compared to the rates quoted by the utility company.
3. Additional investment for the power plant expansion based on firm generating capacity to meet the expected new demand.
4. Most economical block of power to be purchased from the utility company.
5. Possibility of operating in parallel with the utility supply system so as to obtain maximum security with minimum of power bills to be paid for the power purchased.

Most steel plants generating their own power have a tendency to add to their loads to such extents that when a major expansion comes up, they stand rather precariously as regards the firm generating power capacity. It then becomes generally advisable to purchase additional power from an outside electric supply agency, if one such is available, even though the rates quoted are slightly higher than the cost of generation with the existing plants.

Let us take the same case as illustrated in Figure 2. The plant has a safe steam capacity to generate a maximum of 57,000 kw of power. The load is allowed to grow till the generating capacity is just able to meet the works demand. It is then proposed to add new plants with a maximum demand of 15,000 kw and it is decided to purchase power from a multi-purpose electric supply corporation, which could then supply the whole demand of the works if required.

Let us suppose that the electric supply company proposes the following tariff:

(Costs are based on present-day Indian rates converted into U. S. A. dollars at the existing exchange ration of one dollar=4.8 Indian rupees).

1. *Demand charge on 15-minutes basis:*

First 2,000 kva @ $1.25 per kva
Next 3,000 kva @ $1.125 per kva
Next 5,000 kva @ $1.010 per kva
Next 10,000 kva @ $0.91 per kva
Over 20,000 kva @ $0.810 per kva

2. *Energy charge:*

A flat rate of 0.52 cent per kilowatt-hour for all energy consumption within the contract demand charge.

3. *Guaranteed minimum payment:*

Demand charge based on 75 per cent of the contract demand each month and in addition an energy charge on 50,000,000 units per year shall be paid as the minimum guaranteed payments.

TABLE II

Comparison of Installed Capacities at Various Substations as shown in Figure 2

Station	Plant installed capacity, mva	System voltage, kv	Maximum demand, mva	Firm capacity, mva	Interrupting rating switchgear, mva
1. Power House	110	13.8	80	75	750
2. Substation A	20/23	3.45	9	10 (generation)	250
3. Substation B	20/26	3.45	14	13	250
4. Substation C	30/40	6.9	26	26	350
5. Substation D	20/26	6.9	16	13	350
6. Substation E	30/40	6.9	23	26	350

Note: All transformers have a self-cooled rating of 10 mva and fan forced cooled rating of 13 mva.

Let us also assume for comparison that the generation cost for the energy produced in the Steel Company's power houses is about $160,000 for 30,000,000 kilowatt-hours generated. Fixed charges are taken at $53,000 per month, and unit generation cost at 0.330 cents per kilowatt-hour.

For the steel company to provide power for its expansion program, there are two alternatives. The first alternative is that the additional demand of 15,000 kw is all purchased and connected independently, and the rest of the plants operated on the works system separately as before. The second alternative is to decide on a higher block of power from the supply company so that the firm capacity of the works is secured as far as possible, and operate the two systems in parallel with the best economy and security. Figure 2 and Table II indicate that in order to secure the firm capacity of the works, it is necessary to contract for 40,000 kva of maximum demand from the supply company. Careful studies of the possibilities of parallel operation of the systems would show that it would be desirable to contract for a demand of 40,000 kva, which would secure the firm capacity of the plant as a whole in an emergency and, at the same time, reduce the power bills from the electric supply company to the minimum.

If the new plants are added to the works system, the additional demand of 15,000 kw added to the original demand of 55,000 kw will create a new maximum demand of about 69,000 kw, taking a reasonable diversity factor of 1.02. The overall power factor is taken at 0.85.

In Figure 3 are drawn the probable load curves showing the proposed division of power between the supply company and works generation. The curves are drawn from assumed data taken on monthly average basis derived from the annual consumption, taking 730 hours per average month. Curve AA^1 indicates the load duration curve for an average month. It is derived from the 15-minute demand figures, plotting the highest figures first and going downwards to the lower figures. A total of 2,920 points plotted against the number of hours as abscissa, will give the curve AA^1, giving the actual load demand curve for the whole plant. It will be seen that the plant highest demand is 69,000 kw and the lowest demand is 34,000 kw. The total area bounded by the curve AA^1 and the axis OX and OY gives the total energy consumption per month. The plant average monthly consumption is thus obtained as 43,250 kw, or about 31,600,000 kilowatt-hour units. Curve CC^1 is plotted in the same manner such that the total monthly energy import from the supply company is

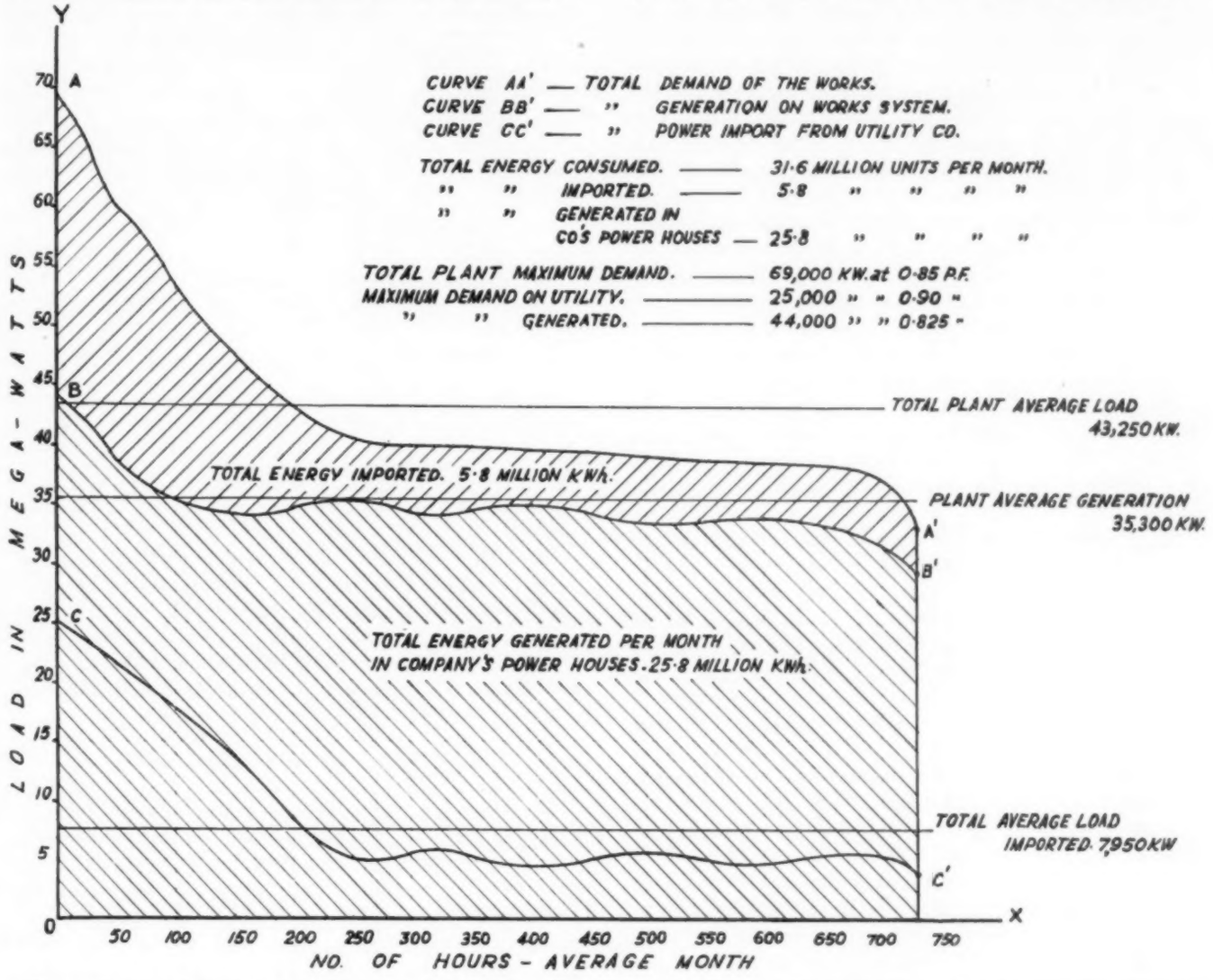


Figure 3 — Load curves show power obtained from plant generation and utility system during an average month.

held to the minimum, so that the charges are maintained as near the guaranteed minimum figures as possible.

The major problem of control is during heavy demand period when the plant load approaches the 69,000 kw mark. Curve BB^1 shows power to be generated on the works power plant so that the demand on the utility system is maintained within the minimum limits.

When the total demand is at 69,000 kw with 0.85 power factor, the reactive kva required by the system is about 42,160 kvar. The minimum demand charge payable to the supply company is 0.75 times 40,000, i.e. 30,000 kva. The maximum demand in kilowatts proposed to be drawn from the supply company system as shown on curve CC^1 is 25,000 kw, i.e. the power from the supply company can be drawn during peak load period at a minimum of 0.825 power factor. As the plant average power factor is 0.85, to have some flexibility and margin on power import in actual operations, the incoming supply can best be drawn at 0.9 power factor. The utility system will thus supply about 12,000 kvar of reactive power. The reactive power supplied by the works power plant is about 30,160 kvar. Total kva power generated on the works system for a load of 44,000 kw is about 53,000 kva at 0.826 power factor.

Thus during maximum demand periods, the loads are so controlled that 25,000 kw at about 0.9 power factor is drawn from the supply company's system, and 44,000 kw at 0.825 power factor is generated in the works.

From the nature of the load curves given in Figure 3, it can be seen that in actual operation, the control of the loads becomes a comparatively simple matter because most of the time the loads on works generation system can be maintained at about a steady value of 35,000 kw, permitting the utility system to share the load proportionately. It is only during the periods of loads between 50 and 69 megowatts that the control of power from the utility system has to be watched. The correct co-ordinated operation can be easily arrived at after actual operation for a couple of months.

Thus the operating conditions are approximately fixed as follows:

1. Plant maximum demand of 69,000 kw and 0.85 power factor is shared between the two power systems, 44,000 kw at 0.825 power factor on works generation, and 25,000 kw at 0.9 power factor on the electric supply company.
2. Of total energy consumption of about 31,600,000 units 5,800,000 units are imported and 25,800,000 units produced on the works generation.
3. The new plants require 15,000 kw maximum demand at 0.86 power factor and 7,650,000 kilowatt-hours energy consumption.
4. Additional consumption of 7,650,000 units is thus divided as 1,850,000 units additionally generated on works power plant and 5,800,000 units imported from the electric supply company.

COMPARATIVE COSTS FOR THE TWO ALTERNATIVES

In Figure 3, it is supposed that 5,800,000 units are being drawn per average month from the electric supply company. However, if the plants are so operated that the power drawn from the supply company is maintained to 50,000,000 units a year, which is the minimum guaranteed consumption, it will be necessary to generate 1,640,000 units per month extra on the works generation, requiring an average load of 36,400 kw. The power bill for the power imports will then be the minimum guaranteed under the agreement. The total cost of the additional power of 15,000 kw at 70 per cent load factor will then be $61,208 per month.

1.	Purchase of additional independent 15,000 kw at 0.86 power factor and 70 per cent load factor, with contract demand of 20,000 kva:		
	(a) Demand charge on 17,500 kva	$17,750.00	
	(b) Energy charge on 7,650,000 units @ 0.52 cents per kwhr	$39,780.00	
	Total Monthly Charges		$57,530.00
2.	Operating the systems in parallel as shown in Figure 3 with a contract demand of 40,000 kva from the supply company:		
	(a) Demand charge on 25,000 kw at 0.9 power factor, i.e. payment to be made on the minimum guaranteed demand of 30,000 kva	$28,125.00	
	(b) Energy charge on 5,800,000 units at 0.52 cents per kwhr	$30,160.00	
	(c) Energy charge for additional generation of 1,850,000 units on works power plant @ 0.330 cent per kwhr	$ 6,039.00	
	Total Monthly Charges		$64,324.00

It will, therefore, be observed that for an additional monthly cost of $3,678 it is possible to provide the firm generating capacity to secure the plants against a sudden failure of a major power generating unit, by contracting for a demand of 40,000 kva from the electric utility.

Parallel operation of the two systems permits a controlled and most economical electrical operation, giving maximum security depending on the working conditions of the plant as a whole. It therefore pays handsomely to contract for a higher demand and then operate the plants in parallel at the most economical level.

CONTROL OF REACTIVE POWER

Metal rolling processes are inherently highly fluctuating in that the electric loading is heavy when the metal is pressed between rolls in a mill, while the motors carry just light loads during the periods when no metal is passing through the rolls. Thus high power motors operate between light loads to full loads with intermittent heavy load kicks when the metal enters the mill.

Slip ring induction motors with flywheels are very commonly used as they permit good automatic slip-regulation to take advantage of the flywheel effect of heavy flywheels to reduce load peaks on the power system.

Induction motors are however inherently low power factor machines, particularly when lightly loaded, because all their excitation has to be supplied by the power system. Thus in a plant where large induction motors predominate, the problem of average electrical power factor becomes acute, and effective power factors as low as 0.55 are predominant at stations which feed sheet mills, plate mills and merchant mills, which are normally driven by induction motors.

From the data given in Figure 3, it will be seen that

to meet the overall power factor of 0.85, it is necessary to operate the works generators at 0.825 power factor, if the maximum demand in kva on the utility system is to be kept safely below 75 per cent of the contract demand of 40,000 kva. If the system power factor is 0.8, the total reactive power required for 69,000 kw load will be 51,750 kvar. The safe minimum reactive power drawn from the electric supply company is shown to be 12,000 kvar. It means that the works generation will have to be at about 0.74 power factor, i.e. the two major generators will be loaded at 59,500 kva, almost the full rating of the machine on maximum safe heating.

It will therefore be seen that with the works power factor at 0.8, the limit of economical and safe loading of the system is almost reached. If, therefore, the power factor of the system tends to drop below 0.8 during peak load periods, measures have to be taken to introduce power factor correction means in order to operate the system safely and economically.

To maintain a high power factor of the plant as a whole, the following general rules should be observed:

1. Do not allow unnecessary transformer capacity switched on the system in the hope of using it in an emergency. Overcapacity puts unnecessary losses on the system without any commensurate advantages, but increases the reactive loading of the system.
2. Do not use unnecessary over-sized induction motors in the hope of having a cool running machine. Oversized induction motors demand increased reactive power and often create mechanical drive problems, if the acceleration becomes too rapid. Under reversing mill service, oversized motors are more a liability than an asset.
3. Use synchronous motors wherever their use is considered justified and where synchronous motor can easily substitute for an induction motor. Synchronous motors make very good drives for compressors, hydraulic large size pumps, motor-generator sets, steady speed, semicontinuous and continuous mills, and several other drives. Modern selfstarting, self-synchronizing synchronous motors are superior in every respect to slip ring induction motors.

   Synchronous motors are more robust and can be easily designed for higher pull-out torques. They can operate at a leading power factor, improving the power factor of the system.

   Pull-out torque of synchronous motors varies directly as the voltage, while that of induction motors varies as the square of the applied voltage. Under system disturbances, therefore, synchronous motors give a more stable operation, when induction motors are likely to trip off or burn out, if not properly protected.

STABILITY OF POWER SUPPLY

By stability of power supply in steel plants is meant that in case there is a severe fault on one section of the system, other sections should not be badly affected. In an underground cable system using multicore cables, it often happens that a ground fault quickly develops into a phase-to-phase short circuit, causing a severe shock on the system if not quickly isolated.

For normal stability, the following major conditions require specific attention when a primary high voltage system is planned:

1. Duplicate bus bars at the main primary station from which bulk of the power is sent out.
2. Proper sectionalizing of the buses at the major receiving stations, and distribution of outgoing feeders on separate bus sections, so that power supply can be continued in case one bus section has to be down.
3. Short circuit rating maintained within the standard ratings of industrial type breakers.
4. In case of a heavy short circuit in a feeder, the voltage on the section not directly connected to the fault bus should not drop below 65 per cent of the normal voltage.
5. Discriminative relaying which provides duplicate relays, one operating within a few cycles if the fault lies within its operating zone, and the second to be a back-up relay which operates if the first one fails.
6. Designing motors on important services, (such as circulating water pumps, furnace blowers, motor-generator sets, etc.) for pull-out torques of at least 250 per cent of normal full load torque.

The plan shown in Figure 2 is designed to give the maximum stability of the power system and to provide the normal continuity of power. A study of Figure 2 will reveal the following major features of the scheme:

1. The power house main bus is laid out as a standard double bus system, known to power system operators and designer. For the steel plant, the distribution will be of the enclosed, metal-clad, fully interlocked protected type.
2. Front bus is sectionalized over bus section switches into three separate sections, while the rear bus is laid out also in three corresponding sections, but interconnected by bolted links to form a continuous bus.
3. The front and the rear bus sections can be interconnected over bus coupler switches. This is necessary in order that a feeder can be transferred from the front bus to the rear or vice versa, without switching off the power.
4. The bus section and bus coupler switches are fully automatic circuit breakers, the bus section switches are provided with standby protective relays which are set to operate in case a fault on the neighboring bus persists.
5. Two 20,000-kva current limit reactors having 15 per cent reactance are connected over automatic relayed circuit breakers at the two ends of the double bus so as to form a completely closed ring.

   The arrangement thus gives the facilities of a double bus layout, with the flexibility of a ring bus. The system can thus be operated in any convenient manner as desired by the operating engineer.
6. By keeping "Off" any one of the bus section switches on the front bus, the system can be oper-

ated as an open bus in three sections, connected over bus bar current limit reactors.

7. The position of the bus selector isolators are shown in Figure 2 for normal system operation. Load area stations A and B are normally operated on the front bus section to which generator No. 3 is connected; stations C and D are connected to the rear bus to which the two 20,000 kva utility transformers are connected. Station E is connected to the front bus section on which generator No. 1 is operating.
8. When the generators No. 1 and No. 3 are in service, the two front bus section switches are kept open. When the generator No. 2 is brought in service, one of the bus section switches will be closed, depending on whether the generator No. 2 replaces the generator No. 1 or generator No. 3.
9. During normal operation, therefore, the various load area substations can be operated in groups from separate bus sections of the main power house bus, which are interconnected over the bus bar current limit reactors.
10. The advantages of the open ring working are that the current limit reactors are fully effective in case of heavy short circuits. It will be seen that if a persistent short circuit is not cleared in time, the voltages on the neighboring buses will not be lower than 65 per cent, the instantaneous voltage drop being limited to 27 per cent, based on 15 per cent subtransient reactance of the generators.
11. The stability of motors connected to the sections of the system not directly affected by the short circuit would remain within their stability limits. Induction motors with 250 per cent pull-out torque, if fully loaded, will still have a pull-out torque of 105 per cent at 65 per cent of their rated voltage. If, therefore, the motors are properly relayed, they will hang on to the system for a longer time. The stability of operation is thus proportionately raised. Synchronous motors will have much greater stability, because their pull-out torque varies directly as the voltage.
12. The distribution of loads on the bus is such that only a part load flows over the bus section reactors. The reactors are protected by automatic circuit breakers on both sides. If an overload flows for a short time, only alarm is given, while automatic tripping is set for higher values. Reactors can also be selectively isolated if they develop any fault.
13. Open-ring bus short circuit rating of the system is below 500,000 kva. Maximum short circuit rating with the ring closed is limited to 600,000 kva, based on subtransient reactance and symmetrical currents. Standard 750,000 kva station type breakers are therefore proposed.
14. Bus section switches at the receiving stations are kept closed, operating the station with a straight bus. The bus couplers are relayed so that if a feeder breaker on fault does not trip, the bus coupler is relayed in sequence before the main incoming breaker on the bus section open out. Thus total shutdown of the station is prevented.

SYSTEM RELAYING

The feature of relaying which plays an important part in the continuity of power supply is the method of neutral grounding of the system. In steel plants, it is a general practice to ground the system neutral over current limiting resistances, only one machine neutral being grounded at a time. The limitations of such a system are so obvious that the steel plant electrical system designers should consider the arc-suppression method of grounding the system neutral.

The faults even in case of underground systems develop as single phase to ground faults which, in case of grounded neutral, quickly turn into phase-to-phase short circuits if not relayed in time. A faulty feeder even on transient faults has to be tripped causing power failure, if a short circuit is to be avoided.

For systems which transmit power at generated voltage, or systems which have a major substation at 13.8 kv or higher from which power is sent to different load area stations, the compensated earth fault relaying over arc-suppression transformers presents many desirable features for a steel plant distribution. Such a system reduces the ground fault currents to a harmless low value, thus permitting the system to operate on a sustained ground fault till arrangements are made to remove the faulty feeder from service. The stability of the system is thus raised to a very great extent. Reference is here made to the author's paper published in October, 1949 issue of the Iron & Steel Engineer, pages 72-77, where a scheme of compensated ground fault relaying for steel plants is explained.

SURGE PROTECTION

Electrical systems are prone to voltage surges caused either by atmospheric lightning disturbances, system faults or switching surges. It is, therefore, desirable that all important high voltage rotating machines are provided with surge arresters. Machine type lightning arresters, shunted by capacitors (0.25 to 0.5 MF), give the best protection against system surges. The arresters limit the magnitude of the voltage wave, while the capacitors slope down the wave-front. Standard metal-clad high voltage industrial switchgear can incorporate the surge protection equipment, and the steel industry should adopt the same as a standard practice. The small extra cost will be worth its expenditure, if life of vital machinery is thereby increased.

SUMMARY

Flexible and stable electric distribution system is the very nerve center of modern steel plants. It is the responsibility of electrical engineers to provide stable, reliable, simple, yet low cost systems, that can distribute large blocks of power at better voltages and permit smooth disturbance-free operations of the many services of the steel plant. Manufacturing and design improvements in the various power distribution system components such as transformers, switchgear, substations, cables, bus structures, etc., have made possible the attainment of simpler and more reliable systems.

CATHODIC PROTECTION FOR STEEL MILL GROUNDING SYSTEMS

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. . . . grounding practices have advanced tremendously in the past few years . . . .

▲ AS early as 1824, Sir Humphry Davey explained the theory of cathodic protection, but not until the 1920's did industry become concerned as to its merits. These early developments occurred mostly in the pipe line fields related to the oil and gas industry. Later, electric power and telephone industries began adopting the method to protect underground cable sheaths.

The electrical power industry during the past fifty years has developed from a simple and rudimentary one to a complex and diversified system. During this period, many advances have been made in the grounding of circuits and equipment and until a few years ago, it was considered quite proper and conventional to establish a ground electrode by means of burying a large quantity of bare copper wire, or plates in moist earth. These electrodes were excellent for conductivity and longevity, and the electrical engineers were well satisfied, but the corrosion engineers declared these types of ground electrodes were causing deterioration to underground iron and steel structures so it became economical from an over-all standpoint to use iron or steel electrodes. However, the economics seemed well balanced, but the longevity of electrodes was diminished, and the probability of a poor, or no ground connection has fostered cathodic protection for steel mill grounding systems.

A large amount of literature is available on the subject of corrosion as it pertains to metallic underground structures, but a brief review of the fundamentals will be mentioned as follows:

1. The damaging effects due to electrolysis is caused by electric current flow from a metal into an electrolyte, for example, current leaving steel piling and flowing into moist earth and thence back to the source.

2. There are two primary sources of electric current which produce corrosion: stray currents from d-c generators, and galvanic currents from two dissimilar metals in an electrolyte.

It is the galvanic current type of corrosion which will be described and a method of cathodic protection presented.

The primary purpose of a grounding system is to limit the rise of potential on a circuit during fault conditions in order to protect personnel and the equipment involved. In order to limit the rise of potential during maximum fault current, a relatively low resistance to earth is necessary, which makes it mandatory to establish and maintain suitable ground electrodes.

Many factors are involved in the design of an adequate grounding system. Some of them are types of soil, size and number of electrodes, and depth of penetration into earth. All of these factors must be carefully considered and evaluated. First, if the terrain is rocky, sandy or extremely dry, then a low resistance earth electrode is not attainable, if the terrain is loam, clay or combination thereof with sufficient moisture so as to give a resistance of 10,000 ohms per centimeter or less, then a plurality of electrodes will produce a low resistance ground system.

A description of the design and installation of the grounding systems at Fairless Works, U. S. Steel Corp. will present a typical case of cathodic protection of grounding systems.

The terrain and geological formation at the location of the plant site within the bend of the Delaware River consists of a top strata of soil, sand and gravel, with lower strata of gravel, rubble, and silt.

Samples of soil were tested in the research and development laboratory. These readings varied from 10,000 to 90,000 ohms/cm. Field tests on location were made by establishing test rods driven to various depths, these checked closely with the laboratory tests. Based on the above resistivity data, an excessive number of twenty foot rod electrodes would have been required, so forty foot rods were driven deeper into the earth.

A formula was developed whereby ground beds of

any desired resistance could be obtained by installing a plurality of rods and anodes with a ratio of two rods to one anode. A typical ground bed is shown in Figures 1, 2, and 3.

The steel rods were forty feet long by 1¼ in. diameter. The anodes were 10 ft long, 4 x 4 in. square mag-

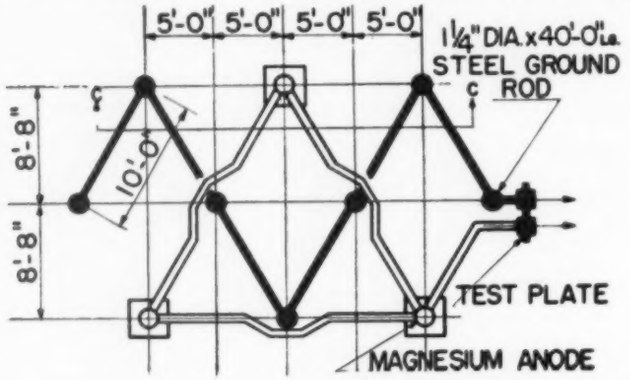

Figure 1 — Ground bed plan shows layout used for steel ground rods and magnesium anodes.

nesium—cast on the center of a 20-ft long, 1-in. diameter steel rod. The rods and anodes were spaced ten to twelve feet from each other which was found to give optimum resistance per minimum number of electrodes.

The rods were all connected in parallel by 250-MCM neoprene jacketed copper cable which was terminated at a test plate. Likewise, the anodes were all connected in parallel and terminated at the test plate.

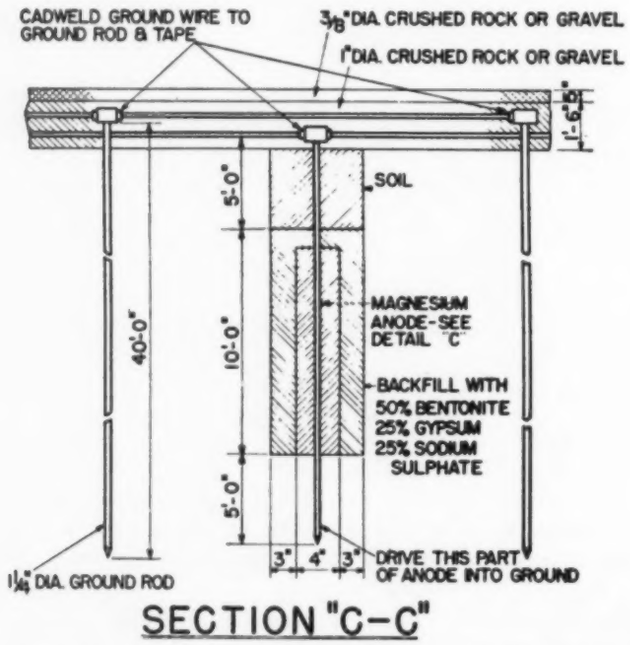

Figure 2 — Vertical section shows that ground rods were driven 40 ft deep.

The test plate facilitates separation of the two elements for checking resistivity and current-voltage characteristics. The test plates also permit separation of equipment ground cables for measuring insulation to ground. Building structure ground cables were also terminated on test plates.

The connecting cables of the grid were 250-MCM neoprene jacketed copper which was welded to tops of rod and anode electrodes, then taped with neoprene tape to eliminate galvanic action between copper and steel. The grid connection cables were supported on crushed rock and covered with same for mechanical protection and drainage.

The rods were given with a rig similar to a pile driver. The anodes were placed in an 8-in. diameter well bored to a depth of 15 ft and then back filled with bentonite,

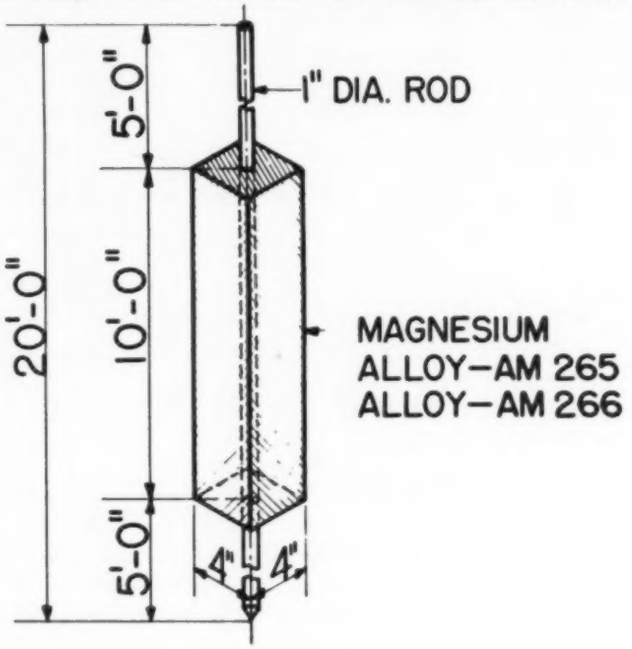

Figure 3 — This view gives details of magnesium anode.

sodium sulphate and gypsum for beneficiation of magnesium to earth contact.

After the grounds were completed, tests were made for resistivity, voltage and current characteristics. Table below shows the readings obtained on May 14, 1952.

Resistance to Earth in Ohms

Location	Mg	Steel	Mg and steel	No. of rods	No. of anodes
No. 1	4.2	3.3	3.0	13	6
No. 2	5.8	3.3	3.1	13	6
No. 3	2.8	2.0	2.0	13	6
No. 4	6.25	3.0	2.8	13	6

Test data forms have been prepared for recording periodic tests, and arrangements made to secure the data and thereby enable control of necessary maintenance of the ground systems as well as furnish valuable data for future reference.

The magnesium anode method of cathodic protection of grounding systems has provided sufficient potential and current to not only protect the steel ground rods, but also has afforded cathodic protection for building substructures within the environment of the anodes. In addition thereto, the grid system resistance has been lowered by the anodes being connected in parallel with the rods.

Based on data of previous experiments, the steel

ground rods with cathodic protection should last indefinitely and therefore assure adequate ground protection. The magnesium anodes will of course deteriorate, but at a rate indicated to last twenty years, or more under present soil conditions, thereby minimizing replacements.

The cathodic protected grounding systems described, not only provide the necessary low resistance to earth for protection to personnel and equipment, but afford cathodic protection to adjacent metallic substructures and thereby present another advance in the field of engineering.

DISCUSSION

PRESENTED BY

WILLIAM B. FERGUSON, William B. Ferguson and Associates, Chicago, Ill.

William B. Ferguson: Had I been permitted to put the grounding system in on the open hearth, which we built for the Fairless Works, the grounding system would have consisted of H-beams, which served as piling, connected with million circular mill cables.

The U. S. Steel people have tenaciously stuck to their requirement, and we went along. I think it is a subject which is going to bear considerable watching in the future, as it no doubt has possibilities. I have had considerable experience with water line failures, gas line failures, due to electrolysis, and it is a very interesting subject.

However, there is one other point which I would like to bring out in connection with this paper, and that is a word of caution. Where the ground beds serve substation areas, particularly, it might be well to give some thought to fault current magnitudes. As Mr. Headlee pointed out, the grounding system is made up of a grid work of 250-MCM cables which connect the bed areas. We found, in one or two instances, that ground fault currents immediately around substations can exceed the current-carrying capacity of these cables. If you are going to stick to 250-MCM cables, it may be necessary to parallel two or more to handle the station fault currents.

Plan to Attend

1954 ANNUAL AISE CONVENTION

AND

IRON AND STEEL EXPOSITION

CLEVELAND PUBLIC AUDITORIUM

CLEVELAND, OHIO

SEPTEMBER 28, 29, 30 . . . OCTOBER 1

AISE WEST COAST MEETING

LOS ANGELES, CALIF.

FEBRUARY 15, 16, 17

The first West Coast meeting in the history of the AISE, held February 15, 16, 17 at the Hotel Statler, Los Angeles, Calif., attracted steel men from all parts of the country. The program featured technical papers by leading steel mill authorities, aimed particularly at problems confronting western plants.

Eric L. Anderson, president of the Association, officially opened the conference with an address of welcome (1). A total of 450 men (2) attended the various sessions (3) during the first two days of the meeting.

Shown in (4) are Emil Kern, co-chairman, E. L. Anderson, and Ernest F. Donatic, co-chairman (standing) with speakers of the initial technical session, Charles E. Smith, Cutler-Hammer, Inc., Norbert C. Rubin, Yoder Co., and Astor L. Thurman, Mannesmann-Meer Engineering and Construction Co. Standing in (5) are G. G. Beard, United Engineering and Foundry Co., and John L. Young and W. F. Pruden, of U. S. Steel Corp., with co-chairmen R. J. Tremblay, Bethlehem Pacific Coast Steel Corp., and W. A. Marshall, Columbia-Geneva Steel, and author E. E. Vonada, Reliance Electric and Engineering Co.

Co-chairmen William A. Perry, Inland Steel Co., and Laurence S. Dahl, Columbia-Geneva Steel, seated (center) in (6), talk over papers to be presented by P. A. Beaman, Morgan Construction Co., (seated left) and L. F. Stringer, Westinghouse Electric Corp., and (standing) W. R. Harris, Westinghouse Electric Corp., Phillip Scarola, Elliott Co., C. C. Brandt, Bethlehem Pacific Coast Steel Corp., and (bending over) R. E. Noble, Mesta Machine Co. Co-chairman John H. Vohr, U. S. Steel Corp., (seated right) in (7) checks an item with co-chairman George B. McMeans, Kaiser Steel Corp., and author W. E. Miller, (center) General Electric Co., as George Grovesnor, Colorado Fuel and Iron Corp., Clarence R. Lohrey, Kaiser Steel Corp., and W. J. McClung, Bethlehem Pacific Coast Steel Corp., look on.

Getting together for a between-sessions chat (8) are Roy McNally and Milo Shutt, of Alliance Machine Co., W. R. Yorkey, Electric Controller and Manufacturing Co., R. G. Widdows, Electric Controller and Manufacturing Co., and E. T. Phillips, Sheffield Steel Co. L. L. Young, Kaiser Steel Corp. (9), R. W. Leech, Westinghouse Electric Corp., and P. A. Beaman, Morgan Construction Co., (seated) join R. J. Pascol, Westinghouse Electric Corp., B. J. Middour, Reynolds Metals, and E. E. Mathern, Kaiser Steel Corp., in a lively session.

John H. Vohr (10) entertains W. G. Hoffman, Aetna-Standard Engineering Co., Cecil Warrender, Mackintosh-Hemphill Co., and M. C. King, Kaiser Steel Corp. Caught in a jovial mood (11) are K. C. Gardner, Jr., United Engineering and Foundry Co., A. W. Steele, Bethlehem Pacific Coast Steel Corp., Charles A. Richardson, of United, Tudor Wall, Kaiser Steel Corp., G. G. Beard, United Engineering and Foundry, and W. J. Bolton, Bethlehem Pacific Coast Steel Corp.

The quartet pictured in (12) is made up of J. R. Gregory, Blaw-Knox Co., Worrell Pruden and H. W. Christiansen, of Columbia-Geneva Steel, and George Andrews, Blaw-Knox Co. Sanford Brooks (13) Tool Steel Gear and Pinion Co., points out an item of interest to R. J. Myers, Tool Steel Gear and Pinion Co., J. F. Mayberry, Inland Steel Co., and K. R. Casey, Kaiser Steel Corp., while in (14) K. L. Johannsen, U. S. Steel Corp., does the same for L. F. Moore, Columbia-Geneva Steel, R. E. Walsh, Continental Foundry and Machine Co., and S. A. Huffman, Kaiser Steel Corp.

In (15) R. T. Lucas, of Weirton Steel Co., catches up on some reading while kibitzers W. E. Miller, General Electric Co., Dennis Miner, Bethlehem Pacific Coast Steel Corp., R. E. Johnson, General Electric Co., and R. D. Bradley and M. M. Mosley, also of Bethlehem Pacific Coast Steel, get into the act. In (16) Frank Alcock, Cleveland Worm and Gear Co., C. W. Chamberlain, Columbia-Geneva Steel, and Carl W. Sinclair and E. J. Ehret, of Cleveland Worm and Gear Co., listen appreciatively as Lee Witzenburg, also of Cleveland Worm and Gear, beats out a tune on the piano. At the reception preceding the stag dinner (17), on Tuesday, February 16, H. H. Fuller, Bethlehem Pacific Coast Steel Corp., talks shop with Barney Dagan and J. L. Ashby, of Kaiser Steel Corp.

Climax of the three-day meeting was the full-day inspection trip (18) to the Fontana plant of the Kaiser Steel Corp.

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CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

Monday, April 26, 1954 — Dinner 6:30 P.M., Meeting 8:00 P.M.

"Comparison of Open Hearth and Electric Furnace Operations in a Cold Metal Plant," by J. H. Girdler, Vice President Operations, Atlantic Steel Co., Atlanta, Ga.

Thomas Jefferson Hotel, Birmingham, Ala.

BUFFALO SECTION

Tuesday, April 13, 1954 — Dinner 6:30 P.M., Meeting 8:00 P.M.

Inspection Trip, Hydro-Electric Power of Ontario, Canada.

"Modernization of Rod Mill at Steel Co. of Canada," by D. W. McLean, Assistant Superintendent of Rod and Bar Mill, Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada.

Henley Club, St. Catharines, Ontario, Canada.

CHICAGO SECTION

Tuesday, April 6, 1954 — Dinner 6:15 P.M., Meeting 7:45 P.M.

"Adjustment and Maintenance of Magnetic Amplifiers," by Paul M. Fischer, Electrical Engineer, Cutler-Hammer, Inc., Milwaukee, Wis.

Phil Smidt's Restaurant, 1205 N. Calumet Avenue, Hammond, Ind.

CLEVELAND SECTION

Tuesday, April 20, 1954 — Dinner 6:30 P.M., Meeting 8:00 P.M.

"Production and Application of Titanium and Titanium Alloys," by Frank H. Vandenburgh, Vice President and General Manager, Mallory-Sharon Titanium Corp., Niles, Ohio.

University Club, 3813 Euclid Avenue, Cleveland, Ohio.

DETROIT SECTION

Tuesday, April 13, 1954 — Dinner 6:30 P.M., Meeting 8:00 P.M.

"New 45-in. x 90-in. Slabbing Mill at Great Lakes Steel Corp., Ecorse, Mich."

1. **"Mechanical Design and Installation,"** by P. C. Vetter, Chief Engineer, Great Lakes Steel Corp., Ecorse, Mich.
2. **"Electrical Design, Installation and Operation,"** by Harold Hoeft, Assistant Chief Electrical Engineer, Great Lakes Steel Corp., Ecorse, Mich.

Dearborn Inn, Oakwood Boulevard, Dearborn, Mich.

PHILADELPHIA SECTION

Saturday, April 3, 1954 — Dinner 6:00 P.M., Meeting 7:00 P.M.

"Comparison of Straight and Tapered Tread for Crane Wheels," by J. A. Bell, Chief Engineer, Bethlehem Steel Co., Bethlehem, Pa.

"Daily Maintenance Cost Control," by William B. Carter, Maintenance Engineer, Alan Wood Steel Co., Conshohocken, Pa.

"Maintenance Aspects of the Corrosion Program at Fairless Works," by K. L. Johannsen, Division Superintendent of Maintenance and Utilities, United States Steel Corp., Fairless Hills, Pa.

Engineers' Club, 1317 Spruce Street, Philadelphia, Pa.

PITTSBURGH SECTION

Monday, April 12, 1954 — Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Installation and Operation of Allegheny Ludlum's 58-in. Hot Strip Mill," by Emil Kern, Vice President in Charge of Engineering, and Earl A. Neeb, Manager, Blooming and Breakdown Mills, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

Alumni Room, University Club, University Place, Pittsburgh, Pa.

YOUNGSTOWN SECTION

Monday, April 26, 1954 — Dinner 6:30 P.M., Meeting 8:00 P.M.

"Electric Resistance Welding of Mild Steel Tubing," by C. W. Thomas, Electrical Engineer, McKay Machine Co., Youngstown, Ohio.

Mahoning Country Club, Girard, Ohio.

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TITANIUM CARBIDE ROD MILL GUIDES GIVE IMPROVED ROD PRODUCTION

▲ PIECES of preformed, sintered titanium carbide (approximately ¼ x 1 x 3 in. overall) used today for rod mill guide-inserts are proving to be one of the industry's most outstanding cost cutters of the last decade. Rod mill yields are being upped—in many cases to 2 per cent, production downtime is decreasing, and scrap generation reduced 80 per cent in addition to improving the finished rod's cross-sectional accuracy and surface finish. These inserts, developed jointly over an 18-month period by engineers of both Kennametal Inc., Latrobe, Pa. and one of the country's largest rod producers, are giving exceptional performance in mills rolling AISI 1010, 1020 and various other grades of wire rods.

Mill downtime usually occasioned by too frequent guide changes has been substantially decreased due to the material's long wear-life. It is not unusual for operators to now go from 200 to 310 hours between guide regrinds. Conventional guide materials normally require replacement and/or regrinding in from 3 to 10 hours of mill operation—10 hours being the maximum rather than the norm.

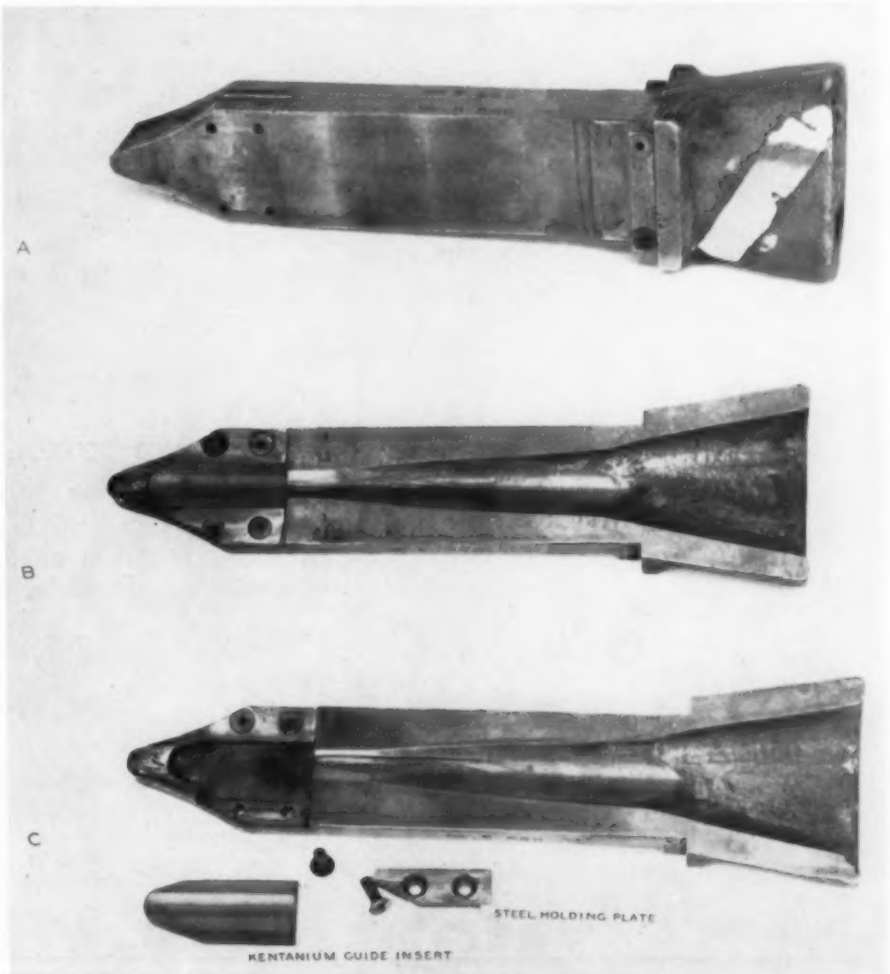
As a matter of interest, a set of these titanium carbide guides which had been reground eight times, produced an average run of 200 hours per regrind for 1600 hours effective guide life. Scrap was reduced to one-fifth of its former quantity.

Unusual properties of this new material make it especially adaptable for handling red-hot rod through the finishing stands of today's high-speed mills at 5000-5200 fpm as well as in lower speed mills at 3200-3500 fpm. Until the advent of Kentanium, rod mill operators advise they never encountered a guide insert material that proved satisfactory for the purpose — including the modern-day tungsten carbides, cast alloys and high-speed steels.

These guide inserts show a wear-ratio as high as 45 to 1 over previously used material. The characteristics of non-galling, resistance to both abrasion-under-heat and shock, lends it to immediate application for hot-wear surfaces where general purpose materials generally fail. Its semi-lubricating action prevents less tendency to drag or pickup, permitting mills to produce higher tonnages due to lessened downtime. Both product finish and cross-sectional accuracy are vastly improved. One of the vexing problems encountered in rod mill operation solved by use of these inserts is that of "tangles" or "cobbles" which quite often are caused by poor guiding of the travelling red-hot rod into the rolls.

While the exact dollar value of savings produced as the result of

Figure 1 — "A" in photo shows typical rod mill guide. "B" shows guide half with Kentanium insert in place. "C" is disassembled view of guide half.



lessened downtime and improved product finish cannot usually be calculated daily, extended periods of testing and recording show these factors contribute considerably to a rod mill's overall yield. An eight-month report from the plant of one of the country's leading rod producers, shows an average net savings in production costs of from $2.25 to $2.75 on each ton of rod produced per 8-hour shift, due to the increased production secured by eliminating much of their downtime previously required for changing short-lived mill guides.

A typical case history involving conventional rod mill guides follows: Abrasiveness of the rod travelling from 40 to 60 miles per hour, at temperatures varying between 1600 and 1800 F, readily caused excessive wear in both brass and alloy guides. They tended to wear in the guiding contact faces permitting the rod to "lay-over" in the guide, which produced a cross-sectional inaccuracy when it hit the rolls off-center. As wear increased in the guides, enough movement resulted to allow the rod to veer off to one side missing the rolls entirely and causing cobbles.

Maintenance of Kentanium guides is relatively simple. All that is required is a simplified machine shop setup where the inserts are easily ground to desired size and finish in approximately 10 minutes per piece. As expensive diamond grinding wheels are not required, these inserts lend themselves to ease and economy of maintenance. Rolling smaller diameter rod or wire may now be a reality for the industry by use of Kentanium inserts. This in turn will reduce today's cost of manufacturing rod sizes which now require drawing operations.

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CRUCIBLE STEEL ENTERS INTO VACUUM MELTING OF STEEL

▲ A development of major importance to the aircraft, electronic, automatic process and metallurgy fields, and to industry in general was disclosed recently with the announcement that Crucible Steel Co. of America and National Research Corp. have joined forces to accelerate development of the vacuum melting of steels and other alloys. Crucible special purpose steels and alloys—metals which must resist extraordinary heat, cold, corrosion and pressure.

Vacuum Metals Corp., the outgrowth of more than ten years of research and development on the vacuum melting process, is currently producing vacuum melted metals and alloys in its plant in Cambridge,

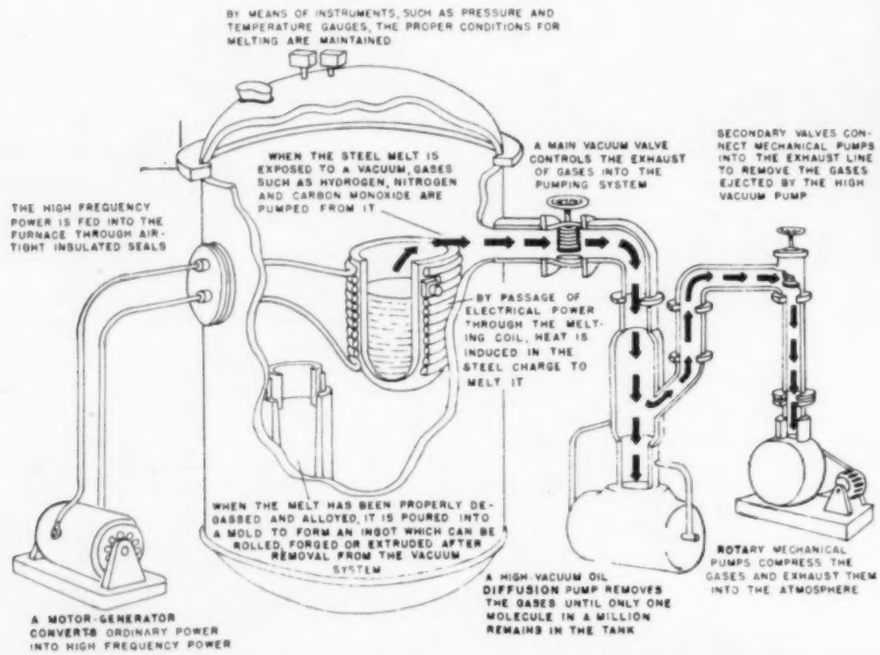
BY MEANS OF INSTRUMENTS, SUCH AS PRESSURE AND TEMPERATURE GAUGES, THE PROPER CONDITIONS FOR MELTING ARE MAINTAINED
WHEN THE STEEL MELT IS EXPOSED TO A VACUUM, GASES SUCH AS HYDROGEN, NITROGEN AND CARBON MONOXIDE ARE PUMPED FROM IT
A MAIN VACUUM VALVE CONTROLS THE EXHAUST OF GASES INTO THE PUMPING SYSTEM
SECONDARY VALVES CONNECT MECHANICAL PUMPS INTO THE EXHAUST LINE TO REMOVE THE GASES EJECTED BY THE HIGH VACUUM PUMP
THE HIGH FREQUENCY POWER IS FED INTO THE FURNACE THROUGH AIR-TIGHT INSULATED SEALS
BY PASSAGE OF ELECTRICAL POWER THROUGH THE MELTING COIL, HEAT IS INDUCED IN THE STEEL CHARGE TO MELT IT
WHEN THE MELT HAS BEEN PROPERLY DEGASSED AND ALLOYED, IT IS POURED INTO A MOLD TO FORM AN INGOT WHICH CAN BE ROLLED, FORGED OR EXTRUDED AFTER REMOVAL FROM THE VACUUM SYSTEM
ROTARY MECHANICAL PUMPS COMPRESS THE GASES AND EXHAUST THEM INTO THE ATMOSPHERE
A HIGH VACUUM OIL DIFFUSION PUMP REMOVES THE GASES UNTIL ONLY ONE MOLECULE IN A MILLION REMAINS IN THE TANK
A MOTOR-GENERATOR CONVERTS ORDINARY POWER INTO HIGH FREQUENCY POWER

Figure 1 — Schematic diagram shows operation of vacuum melting system.

has acquired a 50 per cent interest in Vacuum Metals Corp., formerly a wholly-owned subsidiary of National Research. Vacuum Metals is already producing vacuum melted steels and other metals in commercial quantities, and is the country's only commercial producer of these high-purity metals.

Arrangements have also been completed for construction of new vacuum melting facilities to be located in Syracuse, N. Y., in an expansion program that is expected to increase Vacuum Metals' capacity by more than 500 per cent in the next twelve months.

This important move is consistent with Crucible's primary interest in Mass. Present production facilities permit production at a rate in excess of $1,000,000 annually.

First step toward increasing this production will be the construction

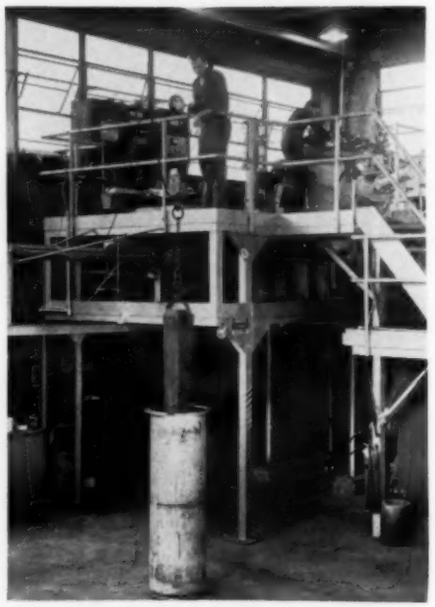

Figure 2 — A 600-lb ingot of special high-temperature alloy is being lifted from mold after vacuum melting and casting.

by Vacuum Metals of a new furnace of 6,000 lb daily capacity at the Syracuse, N. Y., plant of Crucible. Units can produce 3-13 melts in a 24-hr day. Vacuum Metals will also continue the operation of its present furnaces at Cambridge. For the benefit of Vacuum Metals, National Research will intensify its metallurgical research program, including not only vacuum melting processes and products, but also other fields, such as vacuum sintering and the development of protective coatings for metals.

Figure 3 — Operator uses optical pyrometer to measure temperature of molten steel in crucible inside the vacuum tank.

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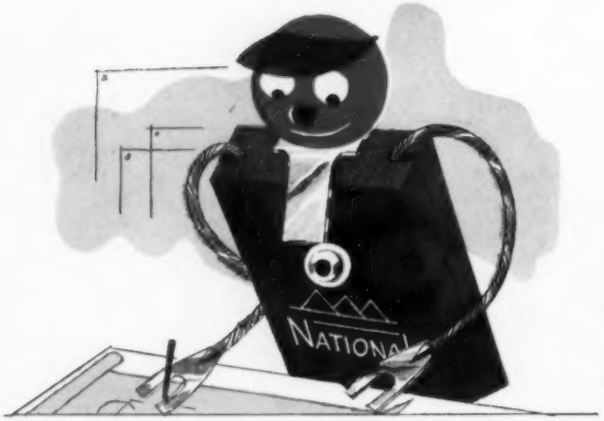

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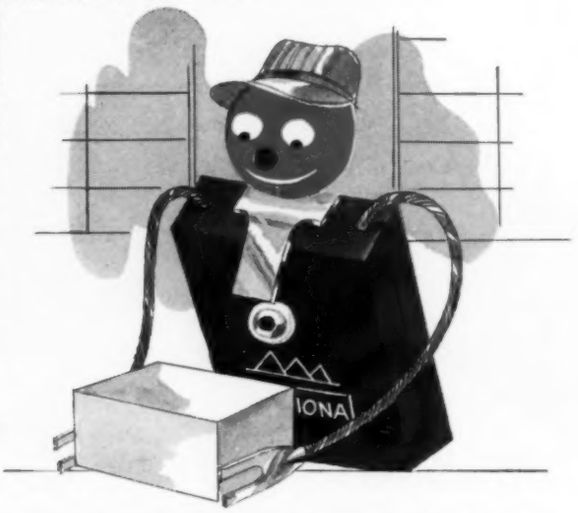

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POWDERED IRON INVADES ELECTRODE DESIGN

By L. K. STRINGHAM
Chief Engineer
The Lincoln Electric Co.
Cleveland, Ohio

▲ HEAVILY coated electrodes containing large quantities of powdered metal in their coatings obtain increased welding speeds on the order of 50 per cent, with appearance in smoothness and freedom from spatter almost equal to that obtained with automatic welding.

The development of electrodes with powdered metal in their coatings is a milestone for metal fabricating industries. Although these electrodes are still new, (commercially introduced with Jetweld in October of 1953 by The Lincoln Electric Co.), cost reductions already obtained in production welding indicate that welding procedures will shortly be completely revised to new standards. Powdered iron electrodes will obsolete existing electrodes. This is not an opinion but is a calculated engineering conclusion. The basic fundamentals of the arc welding process have led inevitably to the development of powdered metal coatings and, therefore, inevitably secure their position in welding progress.

In general, as welding current increases, the speed of welding increases. The electric arc drawn from the end of a welding electrode performs the three functions of melting the core wire, melting the coating of the electrode, and melting the edges of the parts to be welded together. An increase in welding current increases the speed with which the arc can perform these functions. For any given size electrode, welding speeds can be increased until a maximum usable current is reached. Beyond this maximum current of further increase causes difficulties which result in unsatisfactory operation. The difficulty may be an overheated electrode causing a breakdown of the coating, it may be too much penetration, gouging of the parent metal or too much spatter. In any case, the effect is to impose the top limit on welding speed.

Electrodes with powdered metal coatings are designed to raise this top limit on welding speeds by eliminating or reducing the effect of these difficulties.

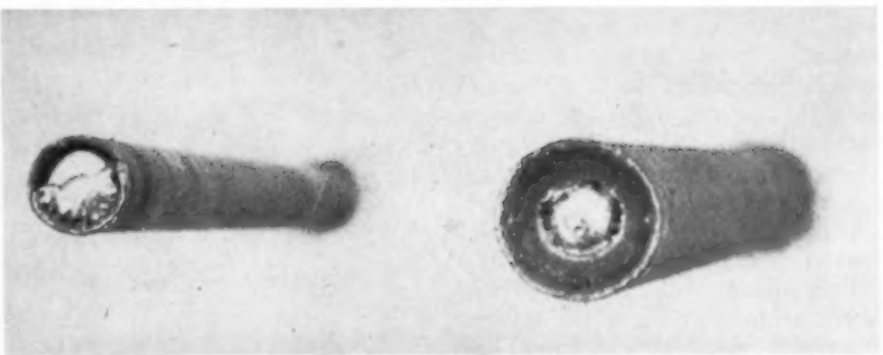
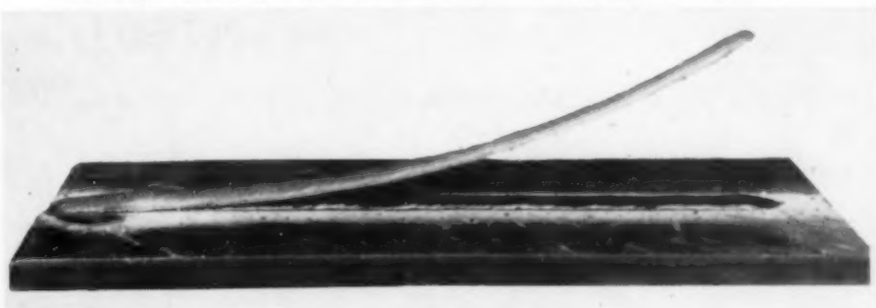


Figure 1 — Partially used conventional electrode left, electrode with powdered metal coating right; shows difference in thickness of coatings and how crucible forms in the end of the thick powdered metal coating. This gives automatic control of mechanical arc length since drag technique is used in operation and controls arc action to give a smooth steady arc.

Figure 2 — Slag formed from powdered metal coating is practically self cleaning. This slag has lifted from the bead by itself as it cooled.



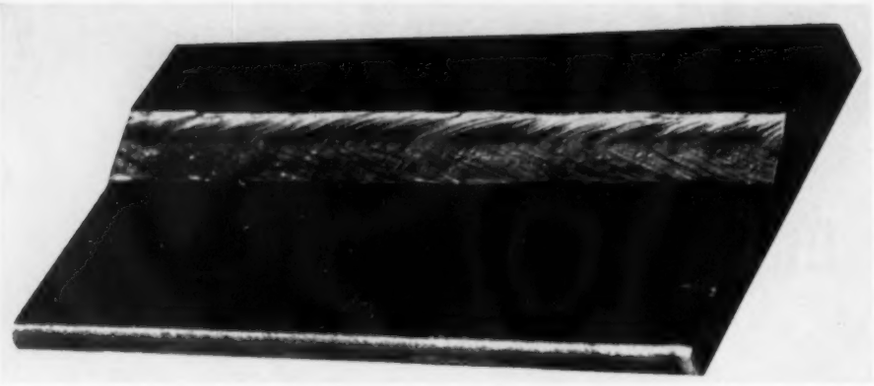


Figure 3 — Powdered metal coatings produce smooth, clean welds, comparable to those produced with automatic welding. This is a horizontal lap weld made in ¼-in. plate with a ¼-in. diameter electrode. Current is 360 amperes, arc speed 18 inches per minute. Conventional electrode, E-6012, calls for 320 amperes current and 12-in. per minute arc speed.

The major cause of operating difficulties that limit welding speeds is the fact that the welding arc normally creates more heat than can be effectively used by conventional electrodes in melting the parent metal, the core wire and the coating. This excess heat usually is expended in melting an excessive amount of parent metal. The arc force throws this excess and some of the melted core wire out of the molten pool. The result, depending on the application, may be too much penetration, gouging, undercutting and spatter. The correction for the difficulty with conventional electrodes is, of course, to cut back on the amount of current used and slow up welding speeds until satisfactory operation is obtained.

Electrodes with powdered metal coatings use the excess heat available in the arc to increase welding speeds. The powdered metal in the coating is melted by this heat and becomes an additional source of metal for the weld, thus permitting an increase in welding speeds. The difficulties of excess current, spatter, gouging, undercutting, are minimized, and additional metal is available to make full welds at the higher speeds. If an electrode contains sufficient iron powder in the coating to supply one third of the deposited metal from the coating and two thirds from the core wire, that electrode can deposit metal 50 per cent faster than the same size electrode without iron powder in the coating. Proper balance is necessary between coating and core wire, for if too much iron powder is put into the coating, so much of the heat of the arc may be absorbed by melting the coating that there will not be enough to melt the parent metal and core wire.

In addition to reducing spatter, undercutting and gouging, this more efficient use of arc heat by powdered metal coatings also reduces overheating in electrodes. Overheating is an operating difficulty frequently encountered on welding applications where the rate of metal deposition is the only controlling factor on welding speeds. The temptation is to push welding current up to its maximum since current controls the rate of metal deposition. The danger is that of overheating the electrode to a red hot condition by forcing it to carry more current than its size warrants. A red hot core wire will break down the electrode coating so that it cannot satisfactorily perform its functions. The limit to welding speed, therefore, becomes the maximum current which can be used without producing a red hot core wire.

Powdered metal electrodes effectively raise the limit on welding speeds imposed by the current carrying capacity of the core wire. More metal is available for deposition and the more efficient use of the arc heat permits increasing welding speeds without necessarily increasing currents.

For the electrode consumer, the efficient use of arc heat by powdered metal coatings means:

1. Lower welding costs through higher welding speeds.
2. Lower cleaning costs because of less spatter and undercut.
3. Smoother and more uniform welds.

TABLE I

Typical Currents and Speeds

Electrode size, in.	Current, amp	Polarity	Fillet size, in.	Arc speed in. per min
5/32	225	AC	7/32	15
5/32	200	DC (+)	7/32	12.5
3/16	275	AC	1/4	15
3/16	250	DC (+)	1/4	12.5
7/32	300	AC	9/32	15
7/32	270	DC (+)	9/32	12.5
1/4	350	AC	5/16	14
1/4	300	DC (+)	5/16	12

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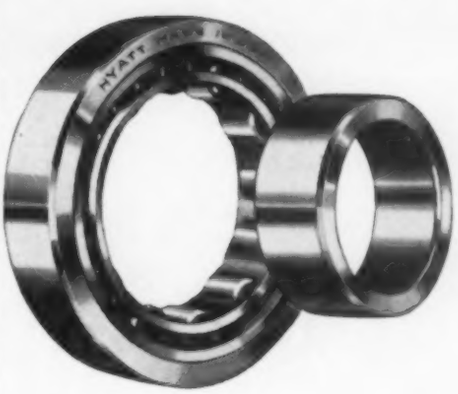
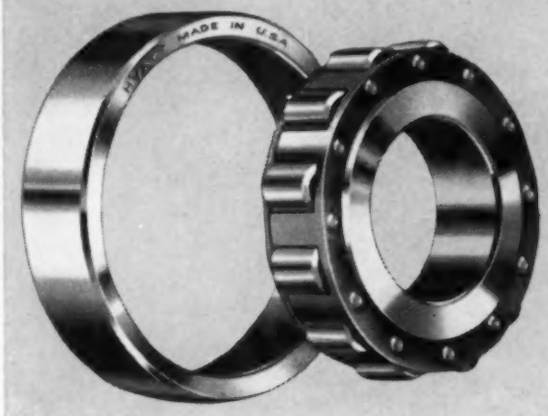
3 ways to handle your RADIAL LOAD PROBLEM

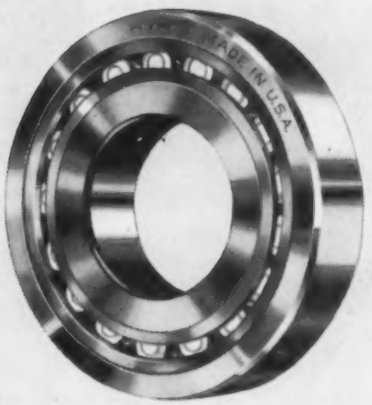


1 If your design requires a large shaft diameter to produce greater rigidity without disturbing boundary dimensions, a separable inner race type Hyatt Hy-Load bearing can be used with the inner race omitted. Rollers operate directly on a suitable hardened and ground shaft.



2 When the housing bore must be kept to a minimum, a Hyatt Hy-Load bearing with a separable outer race can be used—with the outer race omitted. The rollers then operate directly in a housing bore of suitable hardness and finish.

If your design applications involve radial loads, the best way to handle the job is with Hyatts—for Hyatt offers industry's most complete line of straight radial roller bearings! Hyatt Hy-Loads, for example, are made in three diameter series and two basic widths, to standard dimensions. There are ten major types—for the heaviest radial loads, and light or intermittent thrust loads. Four have separable inner races, two have separable outer races and four are non-separable, thus permitting wide flexibility in design and assembly procedures. Write for our general catalog No. 150—it will put the solution to any roller bearing problem at your fingertips. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.



3 For designs requiring a bearing installed as a unit, there is the non-separable type of Hyatt Hy-Load. Whether you select a separable or non-separable type of Hyatt Hy-Load, they are available in a wide range of sizes.

HYATT

ROLLER BEARINGS

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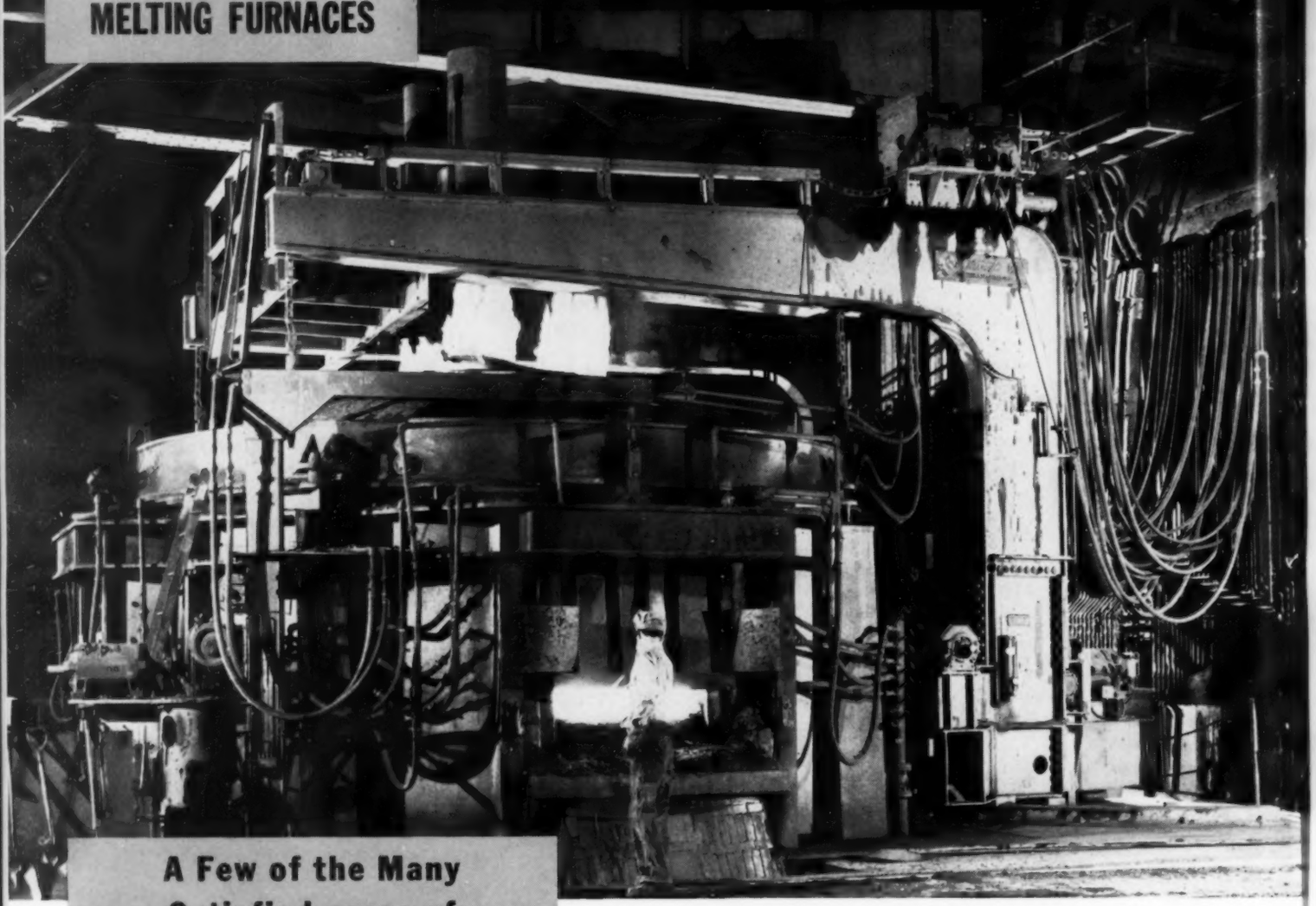

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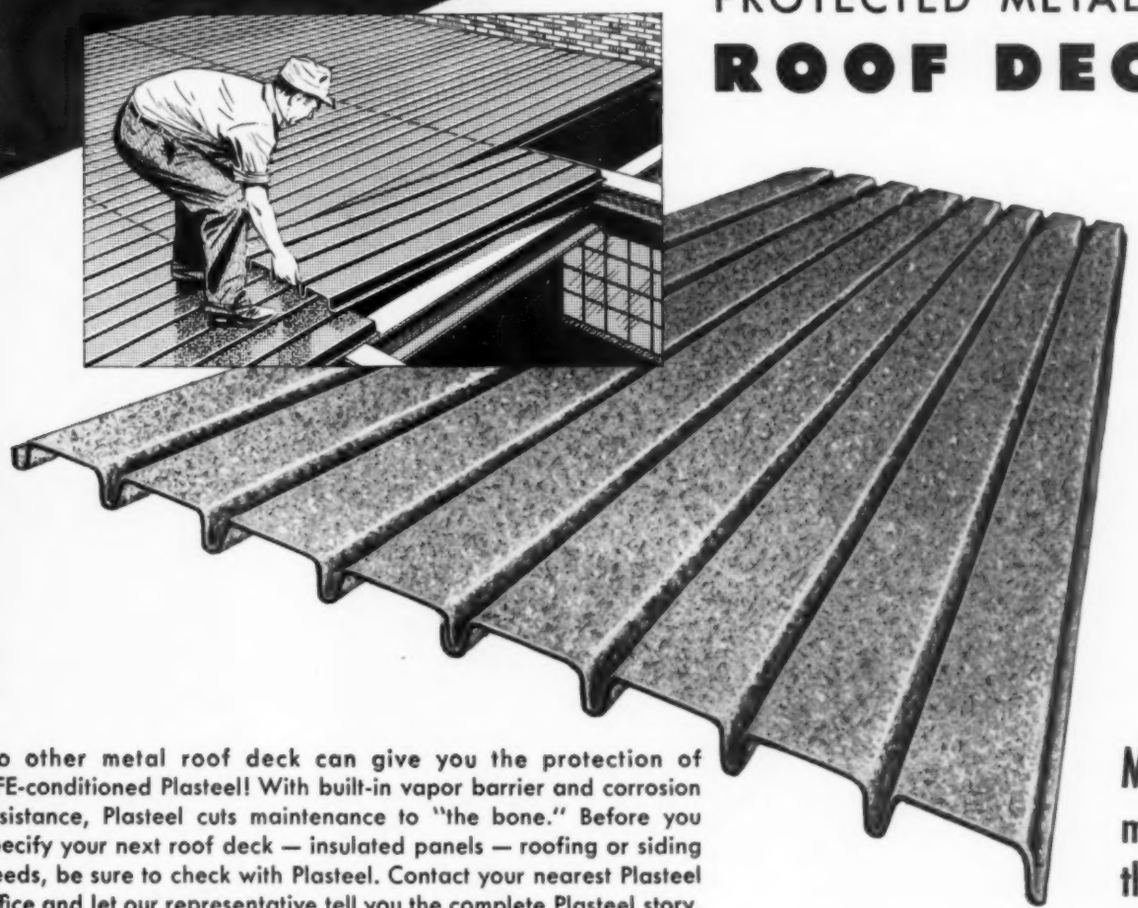

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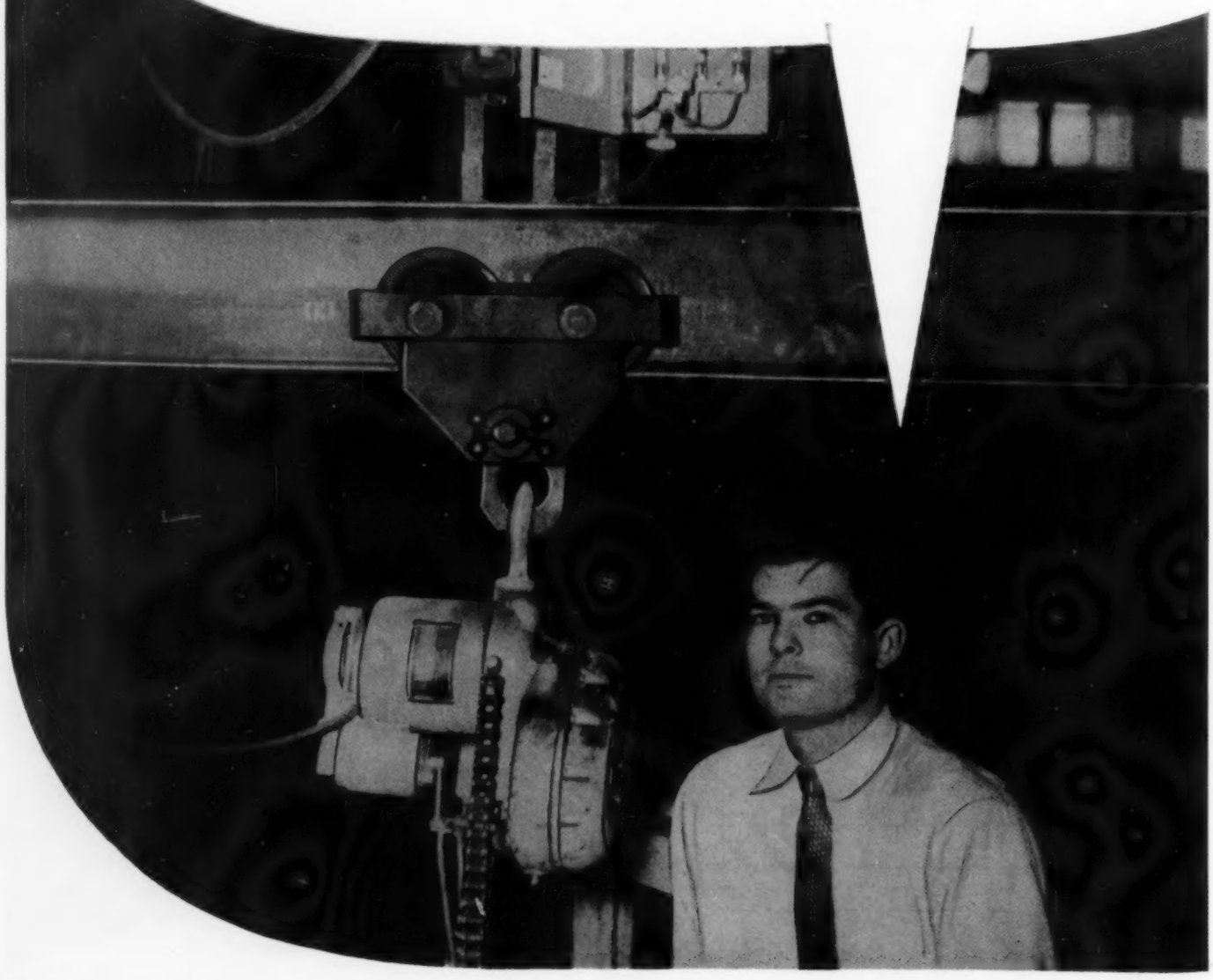
"We were losing as many as six hoist motors a year— now instead of rewinding burned out motors we simply replace blown Fusetron Fuses"



"WE have two 1 ton hoists that are subject to very heavy loading. The motors on these hoists are 220 volt, 60 cycle, 3 phase type with a running current of about 3.7 amperes.

"Whenever the hoists are overloaded an excessive current is drawn by the motor. We have lost as many as six motors a year because of this.

"In the fall of 1952 we replaced all fuses protecting the motors with 4 ampere, 250 volt type FUSETRON dual-element fuses.

"Since then we have blown three sets of FUSETRON fuses but have not lost a single motor.

"So now instead of rewinding motors we simply replace blown FUSETRON fuses.

"They are a lot cheaper than a motor repair job — and we don't have our hoists shut down but for a few minutes while the fuses are replaced."

W. F. Fuertges
Production Superintendent.
Hotchkiss Steel Products Co.
Bradford, Ill.

FUSETRON dual-element fuses can save you money in more ways than protecting motors — they give 10 point protection.

1 *Protect against short-circuits.
2 Protect against needless blows caused by harmless overloads.
3 Protect against needless blows caused by excessive heating—lesser resistance results in cooler operation.
4 Provide thermal protection—for panels and switches against damage from heating due to poor contact.
5 Protect motors against burnout from overloading.
6 Protect motors against burnout due to single phasing.
7 Give DOUBLE burnout protection to large motors — without extra cost.
8 Make protection of small motors simple and inexpensive.
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10 Protect coils, transformers and solenoids against burnout.

*Fusetron Fuses have high interrupting capacity as shown by tests of the Electrical Testing Laboratories of New York.

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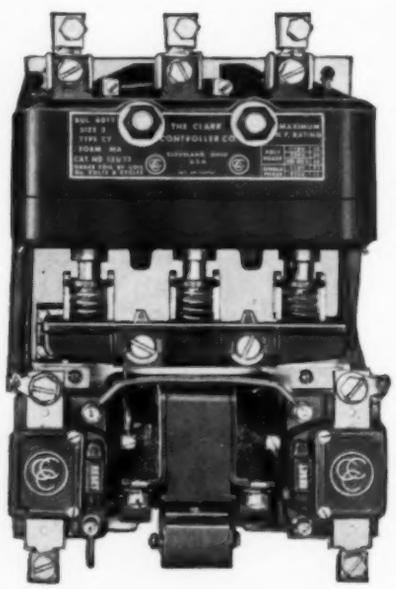
PROOF OF LOW MAINTENANCE ON CLARK TYPE "CY" STARTERS

These unretouched photos show contact tips from a CLARK Bulletin 7707 contactor—the contactor used in the standard Bulletin 6013 size 2 AC Motor Starter — as they looked before and after a year of hard use.

The contactor is in service at Cleveland Hone and Manufacturing Company, on a special transformer and rectifier circuit used in processing automotive parts. The tips shown right above were removed from the contactor after 12 months of steady service, often operating as frequently as 5000 times per hour.

Note that slight discoloration and minute pitting are the only evidence of wear. They require no cleaning, dressing or filing, and are in condition to give many more years of dependable service.

The secret of long contact life in the CLARK Type "CY" Starter is its exclusive arc-quenching principle, using strong multi-turn magnetic blowouts and double-break contacts. Forced rotation causes the arc to move continually on the contact surfaces, distributing the heat and preventing pitting or "build-up" at any one point. Result: extremely effective arc interruption, and greatly reduced wear on tips.



CLARK Type "CY" Starters include many more features for dependable service and reduced maintenance. Let us tell you the complete story.

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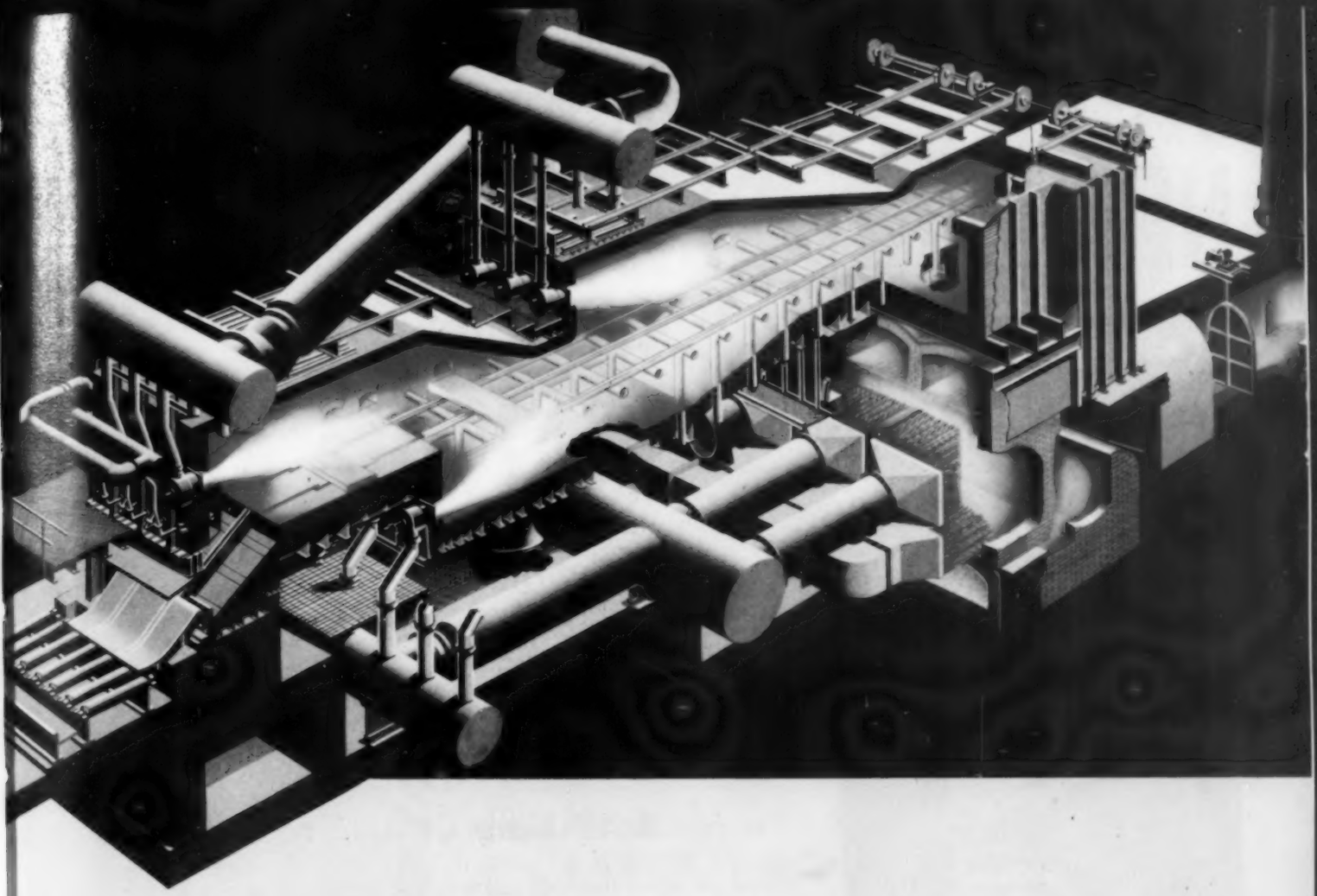

Prime example of Salem-Brosius' furnace-engineering ability

The huge industrial furnace illustrated here attests to the superior engineering skill of Salem-Brosius. One of a few of its kind in the country, it is a pusher-type, triple-fired slab heater currently feeding the giant hot strip and sheet mills of a great steel producer. It features high capacity heating and soaking zones, heavy construction, recuperators for fuel economy, dual gas-oil fuel system, and many other advantages to assure positive, automatic control of furnace output and heating quality. *And the efficiency, economy, ease-of-operation, and trouble-free service this furnace represents are typical of all the furnaces Salem-Brosius builds.* Whether you require conventional heating or heat treating furnaces or furnaces to do an extraordinary job, Salem-Brosius offers equipment designed, engineered, and built not merely as a furnace but as a heating machine. You can purchase these furnaces as complete installations—equipped with all controls, piping and wiring—ready to operate.

Salem-Brosius products—furnaces, forging manipulators, goggle valves, slag granulators, clay guns, charging machines, grab buckets, and special equipment—are engineered for peak performance at lowest cost, because we believe that satisfied customers are our best advertisements. Before you invest in any of these products, we suggest it will pay you to call in a Salem-Brosius engineer and let him study your problem and present a proposal.

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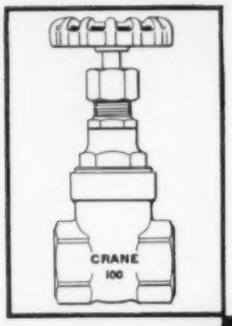
Sales and Executive Offices: 248 Fourth Avenue, Pittsburgh 22, Pa.

NEW* brass gate valves by CRANE



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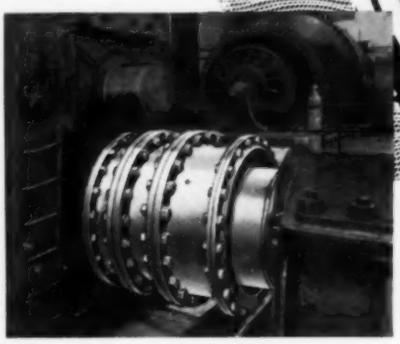

This 30″ Bore Fast's Coupling is on the main drive of the blooming mill at a large Eastern steel mill . . . one of many Fast's linking power to production at this installation.

For SAVINGS up to $30,000 per hour... FAST'S Couplings are FIRST!

A coupling failure in the steel mill installation shown here would cost this mill $30,000 for every hour of down-time! That a Fast's Coupling was selected for this vital spot is striking testimony to the reputation for rugged dependability Fast's Couplings have enjoyed through the years. And Fast's guarantees *you* the same protection against costly shutdowns, whatever your coupling applications!

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Dowell engineers are experts in cleaning industrial equipment with solvents. Almost every piece of equipment found in a blast furnace gas cycle has been cleaned by Dowell . . . some while in operation.

Whatever your problem, look to Dowell chemical cleaning service for the practical answer. For complete information, call your nearest Dowell office. Or write directly to Tulsa, Dept. C-29.

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Date-line Diary...

February 1

▲ The AISI reports that operating rate of the steel industry for the week starting February 1 is scheduled at 73.9 per cent of capacity. This is equivalent to 1,762,000 tons compared with 1,802,000 tons one week ago and 2,202,000 tons one year ago.

February 2

▲ Nash-Kelvinator Corp. cut its prices $20 to $210 on its Rambler and Statesman models.

February 3

▲ Bethlehem Steel Co. was awarded a contract by the Navy to build three destroyers at $53,000,000.

▲ Weirton Steel Co. will increase its tin plate facilities one-third with a $77,305,000 expansion program at Weirton, W. Va. Program includes a new electrolytic tin plating line and revamping of 54-in. hot strip mill.

▲ The Sharon Steel Corp. announced consolidated net income for 1953 amounted to $6,709,625 equivalent to $6.10 on the 1,100,000 shares outstanding common stock. Consolidated net income for 1952 amounted to $5,120,414 or $4.65 per share.

February 4

▲ Steel industry earnings were almost 50 per cent higher in 1953 than in 1952.

▲ The Aluminum Association reported primary production of aluminum for the year 1953 totaled 2,504,029,277 lb compared with 1,874,664,367 lb in 1952.

▲ The Commerce Dept. reported individual income at an annual rate of $285,000,000,000 in December. This was $4,000,000,000 above December 1952. The total personal income in 1953 hit a record $284,500,000,000 which was almost $15,000,000,000 or 6 per cent above 1952.

February 5

▲ Manufacturers' inventories rose to $46,900,000,000 at the end of 1953, $2,500,000,000 above 1952. Backlog of orders in December fell to $58,300,000,000, down $17,000,000,000.

February 6

▲ Unemployment declined to 2,119,900 in the week ending February 6, a drop of 8,200 from the previous week.

February 8

▲ The AISI reports that operating rate of the steel industry for the week starting February 8 is scheduled at 74 per cent of capacity. This is equivalent to 1,764,000 tons as compared with 1,774,000 tons one week ago and 2,248,000 tons one year ago.

February 9

▲ Effective today, Lukens Steel Co. reduced the price of its carbon steel plates from $4.20 to $4.10 per 100 lb.

February 10

▲ Business firms cut inventories in December for the third consecutive month, according to the Commerce Dept. Unadjusted stocks of the manufacturer, wholesaler, and retailer on December 31 were estimated at $79,800,000,000, around $3,800,000,000 more than January 1953.

▲ The ARCI announced deliveries of new domestic freight cars for January totaled 4,944 as compared to a total of 4,456 in December. Orders in January totalled 2,953 leaving a backlog of cars on order on February 1 of 27,959.

February 11

▲ Allegheny Ludlum announced that sales and revenues for the corporation in 1953 hit an all time record of $242,091,000, compared with $190,069,000 for 1952. Net earnings were $7,791,000 equivalent to $4.40 for each share of common stock, compared with $3.37 in 1952.

▲ Net earnings of $33,902,462 for 1953 were announced by Armco Steel Corp. This is equal to $6.50 per share on common stock compared with $6.01 in 1952. Production and sales were greater last year than any year in this company's history, with operations at an average rate of 97.8 per cent capacity. Total sales in 1953 were $588,919,900.

▲ Armco Steel Corp.'s president, W. W. Sebald, expects 1954 plant operations to average not less than 85 per cent capacity. Mills there are currently operating at 95 per cent compared with an average rate of 98 per cent in 1953.

▲ The Titanium Metals Corp. of America announced a significant price reduction of over 12 per cent for commercially-pure sheet and plate. This was the result of rapidly expanding production and continuous mill rolling of titanium sheet.

▲ Granite City Steel Co. announced net sales for 1953 of $87,856,000 compared with $74,600,000 in 1952. Profits in 1953 were $6,488,000 or $3.77 a share compared with $2.80 in 1952.

▲ According to the Commerce Dept., retail sales in January amounted to $12,500,000,000, 3 per cent below January 1953.

▲ In Pittsburgh, No. 1 scrap sold at $29 a ton, down $1 from previous cost.

February 13

▲ The F. W. Dodge Corp. reports the January total of building and engineering contracts awarded in the 37 eastern states reached an all-time high at $1,151,987,000, 7 per cent above January 1953 and 28 per cent above January 1952.

February 15

▲ The AISI reports that operating rate of the steel industry for the week starting February 15 is scheduled at 74.3 per cent of capacity. This is equivalent to 1,772,000 tons compared with 1,774,000 tons one week ago and 2,235,000 tons one year ago.

▲ Consumer's slow demand for zinc resulted in a ¼¢ drop to 9¼¢ per lb at East St. Louis.

February 16

▲ National Works of United States Steel Corp. closed its No. 3 blast furnace for a complete relining.

▲ The AISI estimated payroll of iron and steel industry for 1953 at a new high of $3,355,543,000

which more than equalled the combined payroll of 1945 and 1946. The average hourly wage in iron and steel industry rose to $2.267 for the year, an increase of 11.9 cents over the average in 1952. Workers worked an average of 39.4 hours per week, and average employment was 682,800.

February 17

▲ The Interstate Commerce Commission has authorized railroads hauling imported iron ore from Philadelphia to Midwestern steel mills to lower their rates 20¢ a ton.

▲ A net income of $5,110,000 in 1953 was announced by Crucible Steel Co. of America. This equalled $5.28 on their 687,180 shares outstanding common stock compared with $5.66 per share in 1952. The company's net sales in 1953 amounted to $232,276,000 compared with $180,266,000 in 1952.

February 18

▲ United States Steel closed its last beehive coke oven in southwestern Pennsylvania because of a drop in demand for steel and hence for coke.

▲ Steel scrap price has dropped $1 and $2 a ton on open hearth grades in Pittsburgh and Youngstown respectively.

February 19

▲ Lead has been reduced ½¢ a lb to 12½¢ in N. Y., thus bringing cost back to the level it held on May 15, 1953.

▲ Rem-Cru Titanium listed a new titanium price schedule making possible major reductions in many products. This covers bars, billets, sheet and plates. New schedule is based on costs.

February 22

▲ The AISI reports that operating rate of the steel industry for the week starting February 22 is scheduled at 72.6 per cent of capacity. This is equivalent to 1,730,000 tons as compared with 1,779,000 tons one week ago and 2,240,000 tons one year ago.

February 23

▲ Heppenstall Co. invested an estimated $500,000 when they purchased the Chapman-Price steel plant. President R. B. Heppenstall also reported that this purchase is part of a $2,000,000 expansion program.

▲ The Kennecott Copper Corp. will cut several plants' operations to a 5-day per week schedule. This is a result of a marked decline in copper demand.

February 24

▲ Bethlehem Steel Co. took 3 open hearth furnaces out of production at Lackawanna, N. Y. This brings the number of furnaces operating down to 21 out of 34 open hearths.

▲ Salem-Brosius, Inc. has purchased all outstanding stock of the George J. Hagan Co. thus making it a Salem-Brosius subsidiary.

▲ According to the AISI, finished steel shipments in 1953 totaled 80,151,893 net tons, an increase of more than 12,100,000 over 1952.

February 25

▲ January machine tool orders rose to $50,300,000, 15 per cent above December but 32 per cent below the January 1953 level. Estimates for the year's orders are $700,000,000 to $900,000,000, or around one-half the 1951 total.

▲ Two United States Steel Corp. subsidiaries, National Tube and Consolidated Western Steel, listed f.o.b. mill prices for electric-welded pipe in sizes from 24 to 36-in.

▲ The board of directors of Colorado Fuel and Iron Corp. declared a 2½ per cent dividend on common stock.

▲ Canadian total production of steel ingots in 1953 hit a record 4,010,000 net tons, a 12 per cent gain over the record year 1952 of 3,578,000 net tons.

▲ The 1953 annual production of stainless steel ingots rose to 1,015,303 net tons compared to 1952 output of 930,164 tons, a year which was affected by the long strike. The previous record year was 1951 with a total of 933,730 tons.

February 26

▲ The Pennsylvania Railroad's operations in January resulted in a net loss of $3,400,000 compared with a net income of $1,900,000 in January 1952.

▲ A further decline of steel scrap in the Pittsburgh district was a drop of $1 for No. 1 heavy melting grade to $27 a ton.

▲ A report of the AISC stated January shipments of fabricated structural steel amounted to 240,637 tons which was 44 per cent greater than the January average of the Institute's 1947-50 base period. Orders in January totaled 167,036 tons leaving a backlog of work ahead as of January 31 at 1,686,385 tons.

▲ Mesta Machine Co. reported 1953 net income, after charges, of $3,500,416 or $3.50 a share compared with $2.71 a share in 1952. Backlog on December 31 totaled $38,700,000 compared with $53,300,000 at the end of 1952.

February 27

▲ Westinghouse Electric Corp. announced its net income for 1953 was $74,322,000, an increase of 8 per cent over the previous year. Net sales reached a record high of $1,582,047,000.

February 28

▲ General Electric Co. set an all-time record in 1953 with total sales of $3,128,127,000, an increase of 19 per cent over the 1952 total of $2,623,888,000. The net earnings of this company were $165,728,000, 9 per cent higher than 1952, equal to $5.75 per share of common stock compared with a $5.26 one year ago.

▲ Republic Steel reported the total wage and salary payments to employees in 1953 totaled $346,687,000 for a new high.

▲ Interlake Iron Corp. announced 1953 revenues of $80,751,560 with net profits of $5,779,005 or $2.96 a share compared with $2.75 a share in 1952.

▲ Detroit Steel announced completion of its 4-year, $60,000,000 modernization program at its Portsmouth, Ohio works.

▲ Colorado Fuel and Iron Corp. was considering a $2,500,000 improvement program for its rod mill in Buffalo, N. Y.

▲ The H. K. Porter Co. announced it had acquired the business of the McLain Fire Brick Co.

Two 30 ton, 75 ft. span Bedford magnet cranes with 15 ton bucket auxiliaries working over the cinder yard—used as skull crackers in Detroit Steel Company's mill at New Boston (Portsmouth), Ohio.

Bedford Steel Mill Cranes are individually engineered for each specific application

In steel mills, power plants and throughout heavy industry, wherever superior performance is *expected*, experienced owners are enthusiastically recommending Bedford cranes.

Further proof of the superiority of Bedford cranes is found in the high percentage of *repeat orders* from important owners through the years.

Built to the most modern standards and backed by more than 52 years of specialized crane building *and utilization* experience . . .Bedford cranes have won fame the world over for advanced design and for safe, smooth, dependable performance.

Available in all types and sizes . . . from 5 tons to 350 tons, and up, for all kinds of indoor and outdoor services . . . each Bedford crane is individually engineered and precision built for its specific application.

You are invited to consult a Bedford engineer on your next crane problem . . . with all the facts on the table we believe you too will make your next crane a Bedford.

(Write for complete catalog describing Bedford Cranes in detail.)

STEEL MILL CRANES BEDFORD

BEDFORD FOUNDRY & MACHINE COMPANY, INC. • BEDFORD, INDIANA

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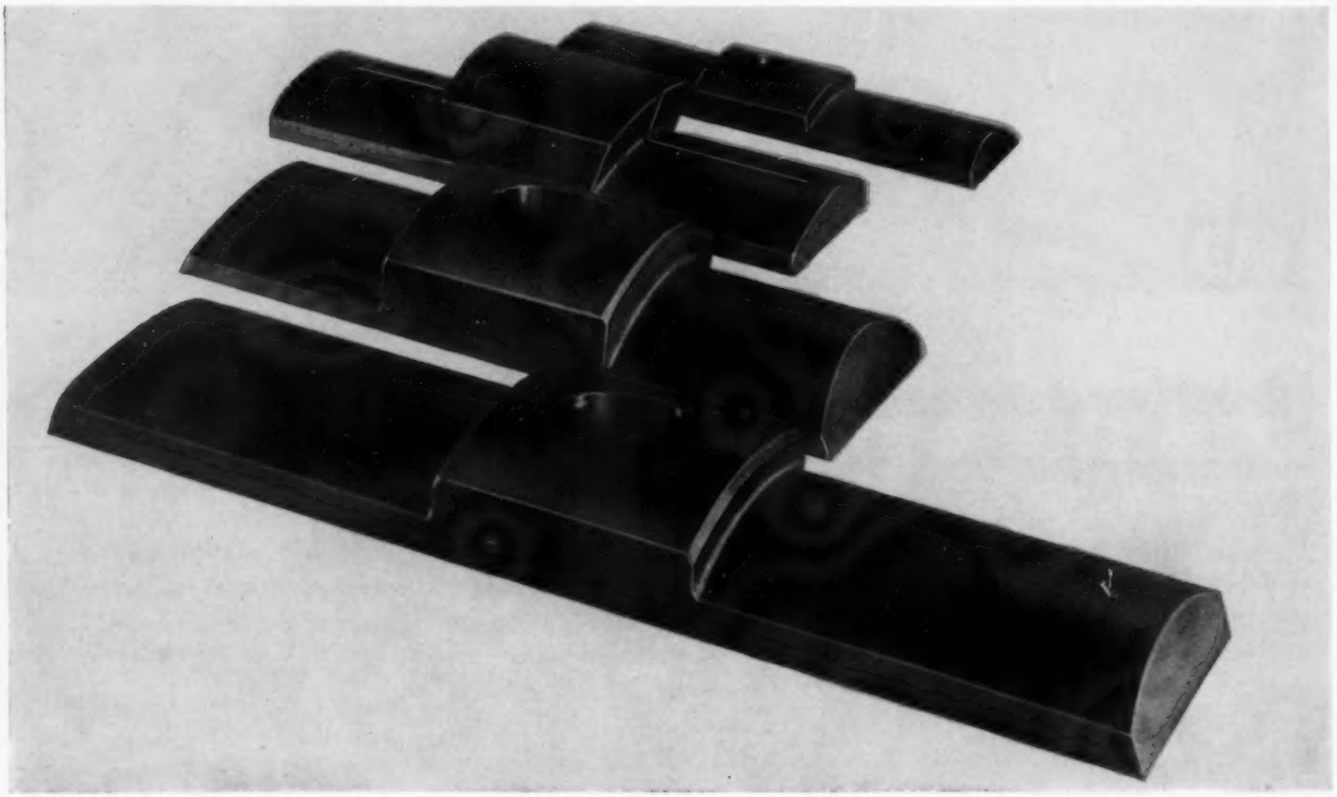
Eliminate machining, extend service life

National Bearing's carefully controlled *permanent-mold* practice makes extremely close-tolerance casting possible. This eliminates the need for costly machining and metal waste. It permits retention of a greater portion of the tough outer cast shell . . . *a guarantee of greater service life.*

These permanent-mold slippers are ready to use when you get them. The use of metal molds assures extremely smooth surfaces and greater metal density due to quick metal chilling. And permanent-mold slippers are considerably lower in price than machined slippers.

If you are interested in lowering your maintenance costs, it will pay you to investigate National Bearing. Six modern plants insure quality workmanship and prompt delivery. They, in turn, are backed by the extensive engineering and research facilities of the entire American Brake Shoe Company.

Write National Bearing Division, 4930 Manchester Ave., St. Louis 10, Mo.



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4930 Manchester Avenue, St. Louis 10, Mo.

BIG

LOADING TOWER

Alliance

TRAVELING LOADING TOWER

This is one of four coal-loading towers on the 1196-foot-long pier of the C. and O. Railroad at Newport News, Va. Each tower can load 1,500 tons per hour.

There are two towers on each side of the pier. Each tower travels the length of the pier and either, or both towers, can completely service a boat. High-speed rubber belts permit complete loading and trimming without manual assistance and with only one mooring. Telescopic chutes and hinged, retractable booms provide easy docking and loading of all ships regardless of type or beam.

These traveling towers are examples of how **Alliance** designs, builds and installs the versatile, efficient machines that make the big jobs possible and practicable.

When your lifting or loading problems get big, really big, call **Alliance** — world's largest builders of the world's largest cranes.

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LADLE CRANES · GANTRY CRANES · FORGING MANIPULATORS · SOAKING PIT CRANES
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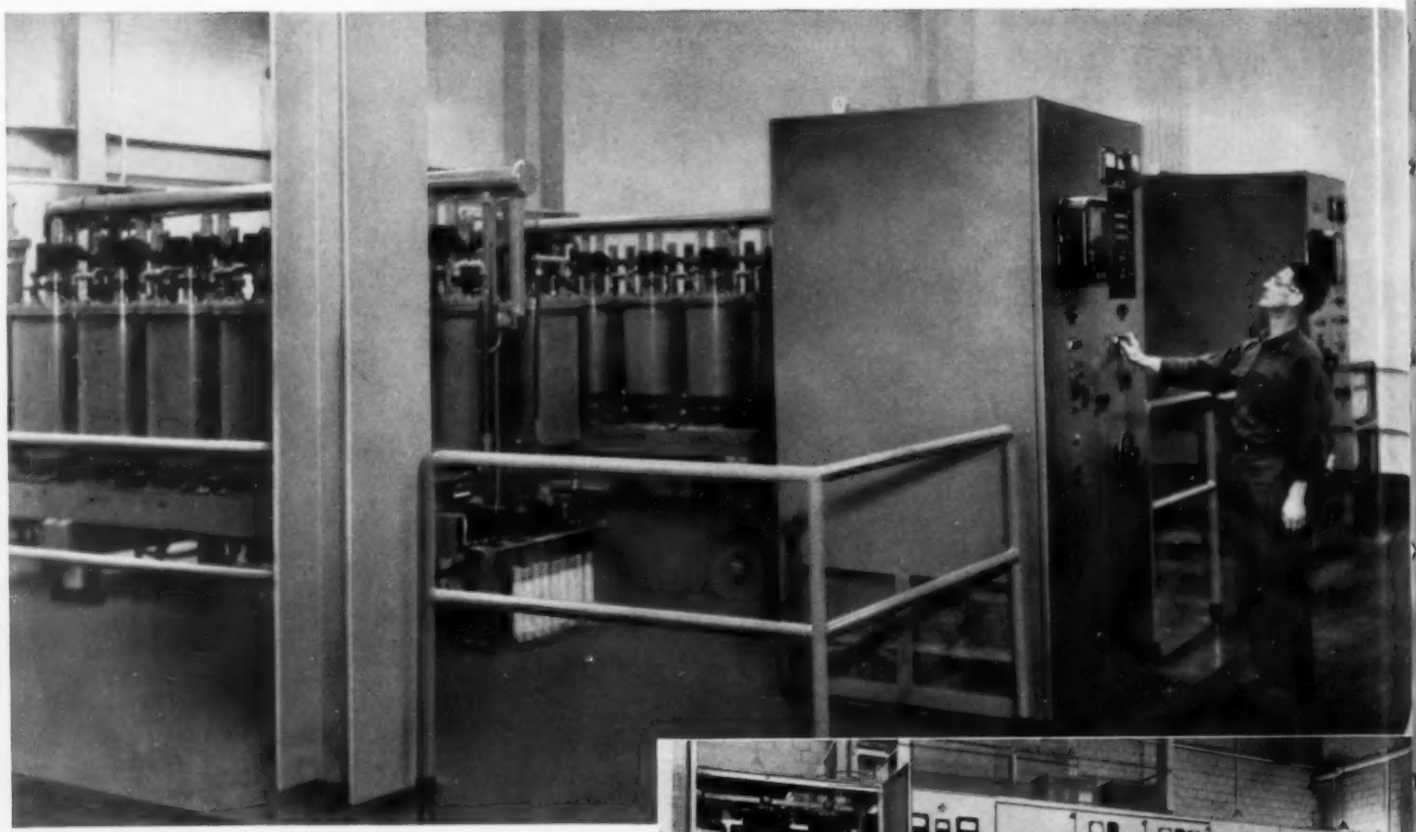
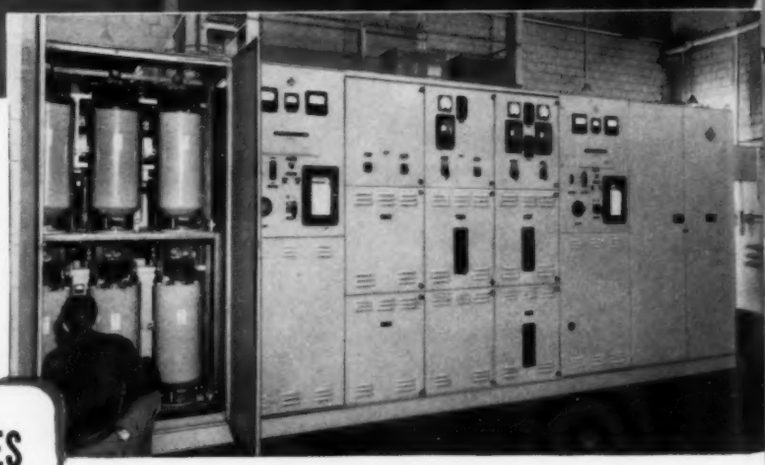
MACHINES · SPECIAL MILL MACHINERY · STRUCTURAL FABRICATION · COKE PUSHERS

100% DC Power for



BILLET MILL RECTIFIERS: Two 1500-kw, 250-volt rectifiers supplying dc service to cranes and runout tables in 30 and 21-inch Billet Mills. Rectifiers are provided with automatic control and provisions for starting and stopping by manual or remote control.



*6 OUTSTANDING RECTIFIER FEATURES

1 **Continuous Excitation:** pilot arcs always present. Eliminates need for synchronized re-ignition. Enables rectifier to ride through severe ac voltage disturbances.

2 **Fixed Excitation Anode:** doesn't contact cathode mercury and is independent of level, turbulence or impurities . . . requires no adjustment, maintenance or replacement.

3 **Internal Cooling System:** high heat transfer with seamless tube cooling located within the rectifier.

4 **Enameled Anode Seals:** multi-layer fused vitreous construction provides high-strength seal unaffected by thermal variation.

5 **Grid Phase Control:** in cleaner region near anode, where ion density is lowest.

6 **Arc-over Free Tube:** insulating entire arc path eliminates danger of arcing-over to tube.

COKE PLANT RECTIFIERS: One of two 500-kw, 250-volt metal-clad rectifier units supplying dc service to coke plant pusher and coke handling equipment in Coke Oven area. Units are factory assembled and wired, complete with dc switchgear and transformers.

ALLIS-

FAIRLESS

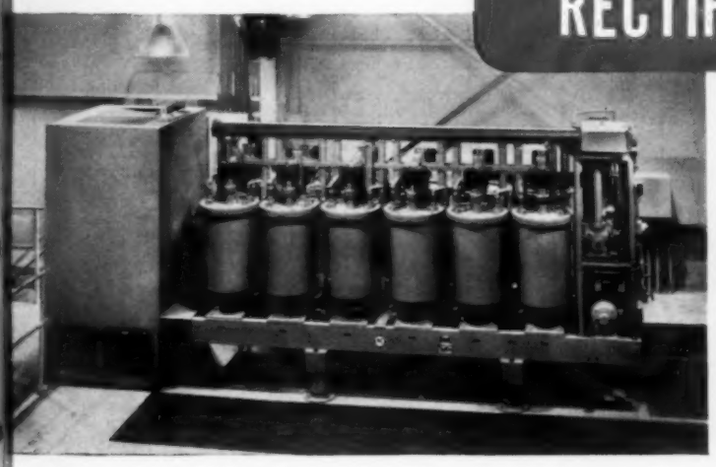
Material Handling

At Fairless Works of the U.S. Steel Corporation — the world's newest and most modern steel mill, continuous dc service is essential to material flow. Any interruption in this critical power supply would cause serious equipment damage and heavy production losses throughout the entire mill. Here, as in other mills over the United States, Allis-Chalmers mercury arc rectifiers are backing up their reputation for continuous, trouble-free operation under variable operating conditions.

In dc load centers located strategically throughout this gigantic plant, 19 Allis-Chalmers rectifiers produce *all* the 250-volt dc supply for every material handling operation . . . from unloading the ore to stockpiling finished steel. These rectifiers are designed and engineered for steel mill duty, and offer highest service reliability and efficiency with low maintenance features necessary for maximum mill output.*

For the same dependable dc service in your mill, specify Allis-Chalmers mercury arc rectifiers. Call your nearest A-C sales office for complete information, or write Allis-Chalmers, Milwaukee 1, Wisconsin. A-4302

ALLIS-CHALMERS
MERCURY ARC RECTIFIERS



OPEN-HEARTH FURNACE RECTIFIERS: One of two 1500-kw, 250-volt rectifiers supplying dc service to cranes, pig casting machines, bailer, slag cars, and stock house equipment. Provided with automatic control and provisions for starting and stopping by manual or remote control.

RECTIFIER TRANSFORMERS: Two 13,800-volt outdoor transformers feeding two 750-kw, 250-volt rectifiers in Central Maintenance shop. Rectifiers supply dc service to maintenance shop cranes, machine tool equipment and provide auxiliary power for electronic testing devices and welding machines.

CHALMERS

A-C ALLIS-CHALMERS

Our Engineers Introduced Mercury Arc Rectifiers to U.S. Industry

How Oxygen...and LINDE SERVICE*

INCREASED INGOT YIELD BY UP TO 10%

As molten steel cools in ingot molds, it shrinks considerably. A cone-shaped "pipe" left in the top of the ingot is "waste" metal and must be removed before rolling. In the past, various methods have been tried to eliminate or reduce this "pipe."

One tool steel company has solved the problem with the aid of LINDE SERVICE. LINDE engineers designed an oxygen and natural gas system that has given the mill an increase in steel ingot yield of up to 10% over former methods. There are further savings, too, because operating costs are far less than for previous methods tried.

***LINDE SERVICE** is the unique combination of research, engineering, and more than 40 years of accumulated know-how. This service is helping LINDE customers save money and improve production in their uses of oxygen and oxy-acetylene processes.

OXY-NATURAL GAS HOT-TOP HEATING

LINDE's oxy-natural gas method of heating metal is extremely simple to use. The equipment is made from standard parts and materials. There is no need for water cooling of blowpipes.

If your company uses oxygen, LINDE SERVICE *can mean dollar savings to you. We'll be glad to tell you more about it.*

LINDE AIR PRODUCTS COMPANY
A Division of UNION CARBIDE AND CARBON CORPORATION
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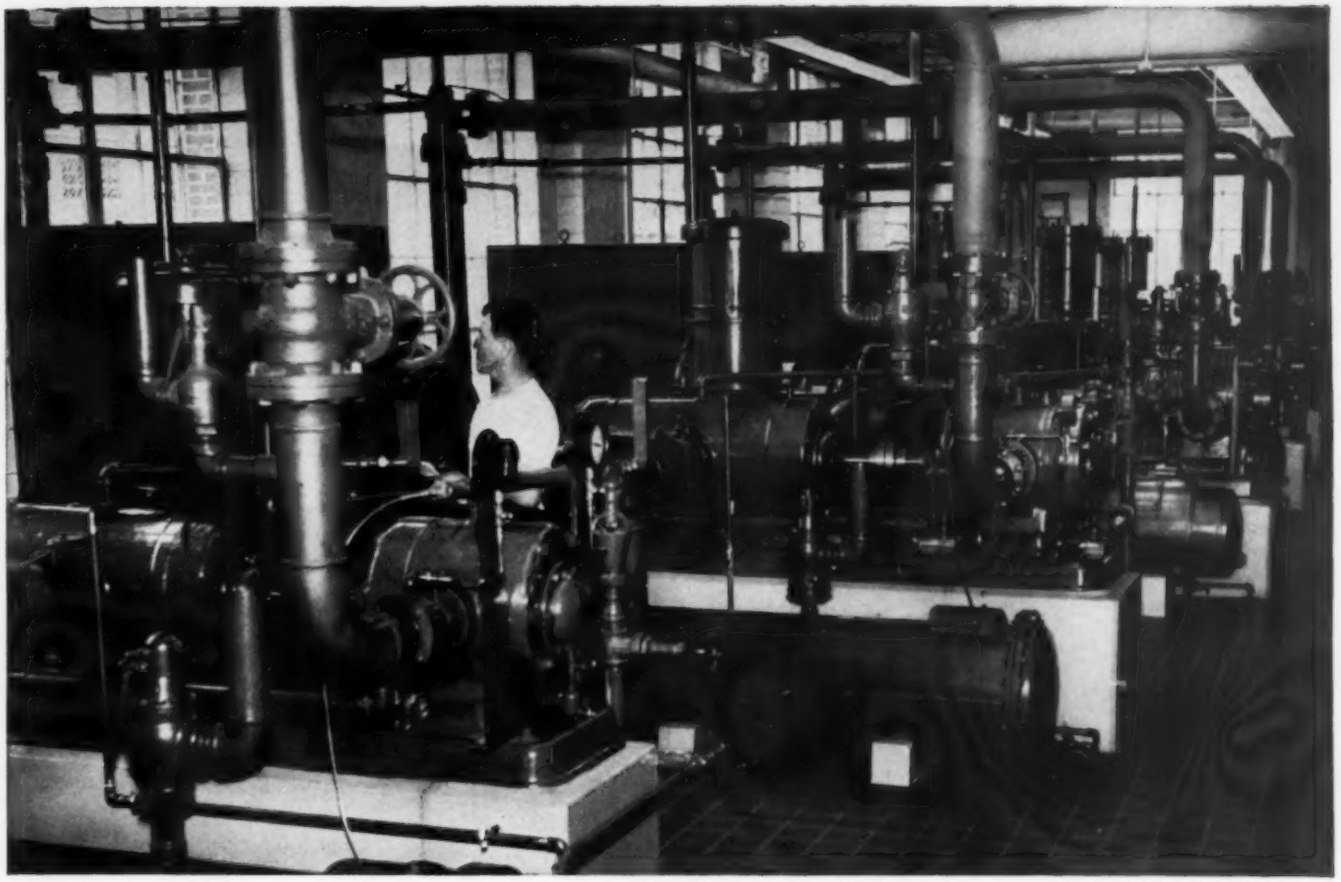

mold Air Power to your needs as this founder does

Six Fuller Rotary Compressors work day after day at Textile Machine Works, Reading, Pa.

Compressed air, produced in one central location, is used for many foundry operations at Textile Machine Works, Reading, Pa., makers of full-fashioned hosiery machinery.

Many molding operations are mechanized at Textile Machine Works, using compressed air. Sand supply-hopper gates are opened by compressed air, jolt-squeeze machines operate with compressed air, pattern plates are removed from molds with air—sand blasting, core making, compacting flask sand, handling push-pallet plates—a whole group of foundry operations simplified by the use of compressed air supplied by Fuller Rotary Compressors.

Starting with a two-stage Fuller Rotary Compressor in 1943, this company has added more compressors as production was increased, until recently the sixth unit was added, supplying a total of 6800 cfm at 125 psi. Each addition was a Fuller Rotary Compressor, a sure indication of reliability and economy of operation.

In your own foundry or process operations, compressed air can save time and money—especially when it is supplied by reliably efficient Fuller Rotary Compressors. Don't overlook the advantages of *air power*—put it to your work—write now for complete information.

Fuller

Pioneers of high-efficiency vane-type rotary compressors

FULLER COMPANY
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SHAPING METAL FOR ALL INDUSTRY

Choose from 11 types of Ohio Iron and Steel Rolls:

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Plants at Lima and Springfield, Ohio

Industry News...

COMPLETION OF EXPANSION PROGRAM DOUBLES INGOT CAPACITY AT DETROIT STEEL CORP. PLANT

▲ Detroit Steel Corp. has announced the completion of the $60,000,000 modernization and expansion program designed to double ingot capacity at its Portsmouth, Ohio plant. The new open hearth shop, consisting of four 250-ton furnaces, was placed in operation when M. J. Zivian, president, tapped the first "heat" of molten steel. This marked the final step of the program which has been underway for nearly four years. At the same time, the company's new 44 x 110-in. hi-lift blooming mill and ten new 18 ft diameter soaking pits were started.

The expansion program at the Portsmouth division of Detroit Steel was unique in many ways. What actually happened was that a new mill was built within the old mill while the old facilities were kept operating practically at capacity.

The new open hearths will reduce material handling costs. This, plus the fact that the Portsmouth plant will be able to use a greater percentage of hot metal from its own blast furnaces, will place Detroit Steel in a more competitive position. The ten new circular soaking pits and the new blooming mill with its auxiliary equipment will further improve operating efficiency.

Previously completed units in the expansion program included a 54 in. hot strip mill started in 1952; a 54 in. cold rolled sheet and strip mill placed in operation early in 1953; and the company's No. 2 blast furnace which was lit last August. This 1400-ton blast furnace is one of the largest and most efficient in the industry.

The old and the new facilities introduced, triple Detroit Steel's pig iron capacity to over 750,000 tons annually and double its ingot capacity to 1,300,000 tons annually.

NEW COKE BATTERY CHARGED AT WEIRTON

▲ Initial charging and pushing of the new No. 8 coke battery was announced by Weirton Steel Co., Weirton, W. Va.

The new coke battery, constructed by Koppers Co., Inc., consists of 41 underjet Koppers-Becker type ovens which are 13 ft high, 40 ft 6 in. in length and 17 in. average width. The ovens have a 3 in. taper from the pusher side to the opposite side where coke is discharged.

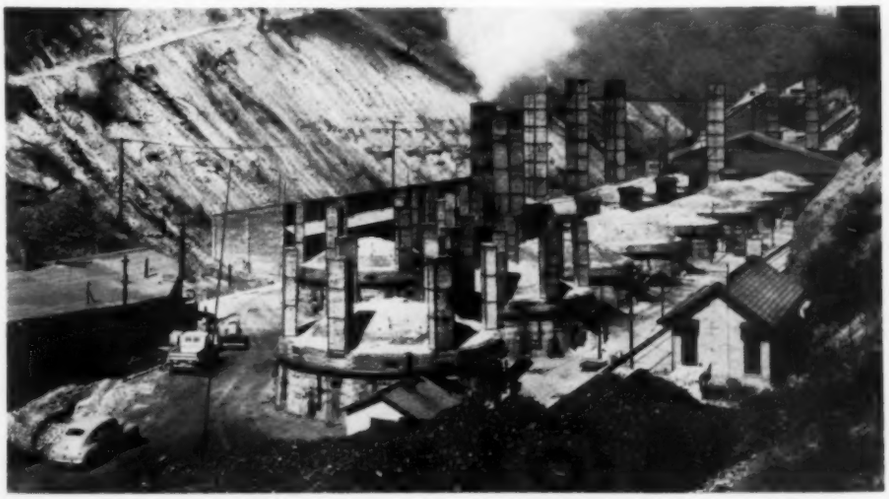
Ovens in the new battery are designed to hold a 17-ton coal charge, this figure being based upon 50 lb per cu ft of coal. The battery will daily consume 1,000 tons of coal and produce 700 tons of furnace coke. The ovens are pushed on a fixed schedule of every 17 hours.

Coke battery No. 1, which consists of 37 ovens and began operating on July 4, 1923, will be dismantled, while batteries No. 2 and 3 were torn down some years ago. The remaining batteries 4, 5, 6 and 7 (No. 7 stands where 2 and 3 formerly stood) plus the new No. 8 battery, will give Weirton a total of 253 ovens capable of producing 4,500 tons of furnace coke per day. No. 4 battery consists of 45 ovens, 5 and 6 have 53 ovens each, and 7 consists of 61 ovens.

The No. 8 battery, which required approximately a year to complete, was constructed at the end of No. 6 battery. These two, along with battery No. 5, make a total of 147 ovens in line.

REFRACTORY FIRM ACQUIRED BY H. K. PORTER CO.

Further expansion as a supplier to the steel industry is planned by H. K. Porter Co., Inc., as a result of the acquisition of the business of the McLain Fire Brick Co., a manufacturer of refractory fire brick, sleeves, nozzles, runners, and hot tops for use in steel plants and metal refineries. Pictured below is the Champion Works, Wellsville, Ohio, one of six plants operated by the McLain Co. Operations will continue as the McLain Fire Brick Co., Division of H. K. Porter Co., Inc. The McLain Co., founded in 1903, produces almost one-half of the pouring pit refractories used in the ferrous industries.



HOLD ANNIVERSARY CELEBRATION IN TENT

▲ Pennsylvania Transformer Co., Canonsburg, Pa., celebrated its twenty-fifth anniversary in a setting that combined a "circus touch" with the more formal dinner atmosphere customary on such occasions. A total of 142 long-term employees were presented gifts to commemorate their years of service with the company.

Despite near-zero temperatures outside, the social activities before and after dinner took place in a large tent, erected especially for the occasion. The tent had been heated beforehand to comfortable room temperature by means of forced-air gas heaters.

Among those honored in the award ceremonies were six employees who have been associated with the company since its founding in 1929.

W. E. Kerr, president, and one of its co-founders, delivered the main address. The other founder of the

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the only complete line of

ALLOY STEEL CHAIN

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● Taylor Made Alloy Steel Chain has twice the tensile strength (125,000 lbs. P.S.I.) of wrought iron chain (48,000 lbs. P.S.I.)!

● This famous nationally advertised chain is heat-treated—never requires annealing!

● It has tremendous resistance to shock, grain-growth and work-hardness at all temperatures!

● All slings are furnished with amazing new Taylor Made Alloy Steel Tayco Hooks!

● Rings, joiner links and other sling attachments are of the same analysis, heat-treated alloy steel as the chain.

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Rush free copy of Booklet No. 12C giving all the facts and specifications on Taylor Made Alloy Steel Chain!

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A GREAT NAME IN
Chain SINCE 1873

company, Samuel Horelick, who retired from active association with the firm in 1952, also spoke briefly to the group.

Pennsylvania Transformer Co. was founded in 1929 and, in the intervening years, has grown steadily until it now ranks as one of the four largest manufacturers of transformers in the U. S. Located in Pittsburgh until the mid-1940's, the entire plant and executive offices now are centered in Canonsburg. In early 1952, the company merged with McGraw Electric Co., whose other divisions manufacture a diversified line of electrical products.

HEPPENSTALL PURCHASES FORMER STEEL PLANT

▲ Heppenstall Co., steel forgings manufacturer, has purchased the former Chapman-Price steel plant in Indianapolis, Ind. In announcing the purchase, R. B. Heppenstall, president, said it was part of a $2,000,000 expansion program.

The newly-acquired plant, consists of six manufacturing buildings and a two-story office building, on a 30-acre tract. The plant has about 190,000 square feet of floor space under roof.

Mr. Heppenstall said the expansion program has been in the planning stage for nearly a year. Because insufficient space was available at any of the present plant locations, sites in a number of different areas were considered. The Indianapolis location was decided on because of the move to the midwest of many of the plants served by the company.

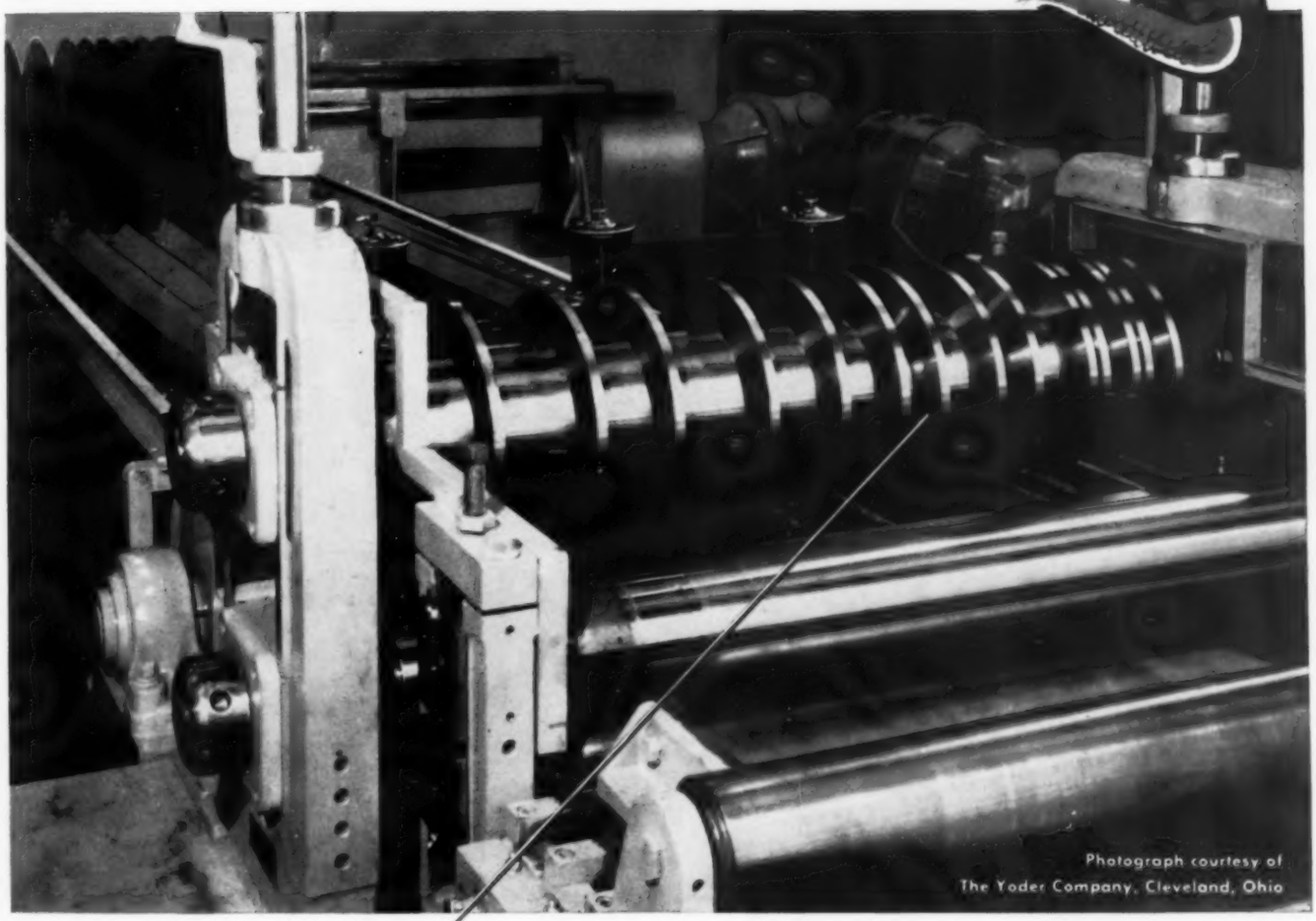
REPUBLIC PLANT WINS FOURTH SAFETY AWARD

▲ The Cleveland, Ohio, plant of Republic Steel Corp. Pressed Steel Division was awarded a plaque for having achieved the best safety record last year among the company's 23 manufacturing plants.

The plant, winner of many state and national safety honors in the past, went through the entire year without a single lost time accident. More than 400 employees worked 786,606 hours during this period. The last lost time accident occurred at the plant on December 16, 1952.

This is the fourth time the plant has won the company award. It also

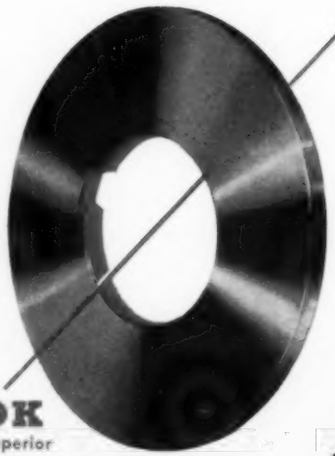
it's OK...let'er go!



Photograph courtesy of
The Yoder Company, Cleveland, Ohio

Watch costs drop with OK slitters

. . . because OK Slitter Knives run hour after hour without re-grinding, giving you top machine productivity at all times. Here's why: exact metallurgical specifications for our steel—an exclusive heat treating process to give uniform hardness and temper—special grinding and finishing to tolerances of ± .00025 or finer.



OK superior performance can cut your cost, speed your production.

Producers for the Metal Working Industry of:

SLITTER KNIVES • SHEAR BLADES • ROTARY SHEAR KNIVES
HARDENED SPACERS • HARDENED WAYS, GIBS, RACES

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THE OHIO KNIFE CO.

World's largest exclusive manufacturers of knives

CINCINNATI 23, OHIO

achieved the best safety records in 1940, 1942, and 1951. The National Safety Council honored the plant with its trophies for excellent safety records in 1940, 1943, 1951 and 1952.

The plant has been a frequent winner of special awards given by the Ohio State Industrial Commission for outstanding safety performance among plants in its type of work. It was named as a group winner in 1939, 1940, 1943, 1944, 1949, 1950, 1951 and 1953. The commission's award is based on the six-month period ending September 30.

TO BUILD STRUCTURAL MILL FOR ENGLISH FIRM

▲ United Engineering and Foundry Co., Pittsburgh, Pa. has announced the receipt of an order from Dorman, Long & Co., Ltd., Middlesbrough, England. This order is for a wide flange beam and structural mill for the rolling of standard structural and wide flange beams up to 36-in.

The equipment to be furnished consists of a 40-in. x 96-in. 2-high reversing roughing mill, including roller tables, manipulators, etc. A 53-in. 2-high universal roughing mill in combination with a 42-in. 2-high edging mill and a 53-in. 2-high universal finishing mill in combination with a 42-in. 2-high edging mill for the rolling of wide flange beams. Included will be front and back mill roller tables, etc. Spare stands will also be furnished by United to facilitate quick roll changing. The 50-in. blooming mill to be used in conjunction with the above equipment will be built in the United Kingdom.

For the rolling of standard structural sections, stands supplied by United, will be set up with 40-in. x 96-in. rolls to form a 2-high roughing and 2-high finishing structural mill in place of the universal roughing and finishing mills used for wide flange beams. This design will give the customer a maximum variety of rolled products.

In addition United will furnish hot saws, saw run-out tables, gauges, etc. Additional auxiliary mechanical equipment will be designed and detailed by United Engineering and Foundry Co. for manufacture in the United Kingdom. Electrical equipment will be furnished by British manufacturers.

PARRY ENGINEERING APPOINTED SALES AGENT

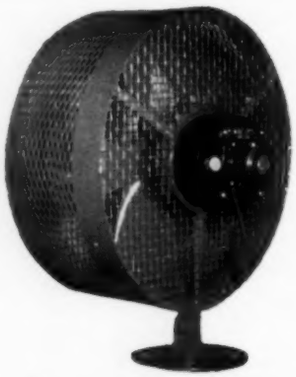
▲ The Parry Engineering Co., 154 Nassau St., New York 38, N. Y., have been appointed as sales representatives for Poole flexible shaft couplings manufactured by the Poole Foundry & Machine Co., Baltimore, Md.

PLAN NEW ADDITION FOR ASHTABULA PLANT

▲ The Reliance Electric and Engineering Co., Cleveland, Ohio, manufacturers of electric motors and power drives for industry, has placed contracts for a new plant addition to its Ashtabula, Ohio, division.

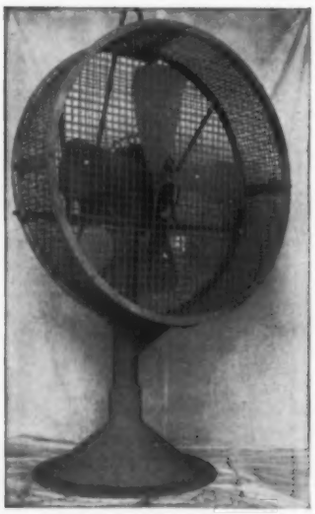
The building will be a single-story, 90,000 sq ft structure of steel, concrete and brick following the architectural lines and duplicating the manufacturing capacity of the company's original Ashtabula plant, completed in 1947. The addition will in-

IS HEAT SLOWING UP YOUR WORKMEN?



TRUFLO CRANE CAB FANS
For cooling interiors of crane cabs and other confined areas. Adjustable both horizontally and vertically. Four blade type, 12 and 18 in. sizes.

Keep them COOL with TRUFLO FANS



TRUFLO PORTABLE COOLING FANS
Easily portable. Help keep efficiency high where work is hottest. 12 to 36 inch diameters.

Production suffers when workmen are overheated. Steps begin to drag, efficiency falls.

Now, when speedy production is vital, Truflo Fans can help keep your workmen on their toes. All Truflo Fans are designed and built correctly to put fresh cool air *in large volumes* exactly where it is needed. Perfectly-balanced shafts and blades give more air per h.p. . . . strong steel frames stand up longer under hard use . . . rugged wire guards protect men against injuries.

All of the following types can help beat the heat, keep production moving in your plant. Write for illustrated literature.

PORTABLE COOLING FANS
CRANE CAB FANS • WALL FANS
EXHAUST FANS • BLOWERS
ROOF VENTILATING FANS
PENT HOUSE FANS

TRUFLO FAN COMPANY
245 MAIN ST. HARMONY, PA.

crease plant and office area to a total of 220,000 sq ft.

The new plant will be used to produce the company's new line of alternating current motors, built to recently-announced revisions in design standards of the National Electrical Manufacturers Association. Meanwhile, Reliance a-c motors of present design will continue to be made in the existing plant at Ashtabula to meet current customer requirements.

COKE PLANT RENOVATION CONTINUED BY REPUBLIC

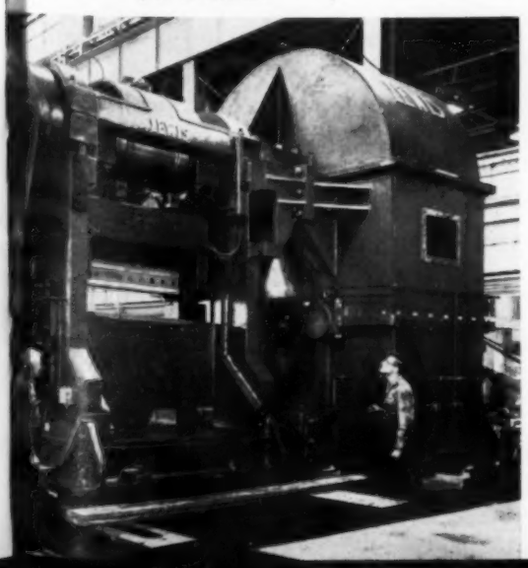
▲ Work has been started on the fourth phase of a multi-million dollar rehabilitation program of the Youngstown, Ohio, coke and coal chemicals plant of Republic Steel Corp.

This phase, scheduled for completion by late summer, will consist of modernization of the benzol plant to improve operating efficiency and quality control. The benzol plant is the last step in the recovery of by-products from coke oven gas. Here, "light oils," such as benzol, toluol and xylol, are removed and processed for use in the manufacture of dyes, synthetic rubber, nylon, phenol, water emulsion paints, lacquers and thousands of other products of the modern chemical industry.

Production of light oils in the Youngstown plant will be somewhat

HOT SLAB SHEAR

Blaw-Knox Co.'s Lewis Machinery Division has shipped a hot slab shear to the Clairton Works of the United States Steel Corp., to be put in operation on their new 40-in. silicon slab line. The accompanying photograph of the shear was taken on the assembly floor of the Lewis Division just before shipment. This shear will cut slabs up to 7 in. thick by 42 in. wide, and will have a continuous running speed of 12 cuts per minute.



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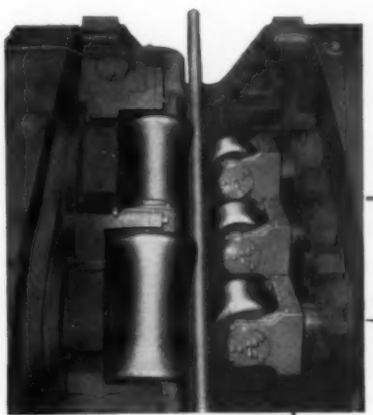
AVAILABLE IN ALL SIZES
For 1/16" to 18 1/2" O.D. Tubes
For 1/16" to 10" Dia. Bars
MODEL 2BM
(Pictured)
TUBES from 3/4" O.D. to 5" O.D.
BARS from 3/4" Dia. to 3 1/2" Dia.

Steady dependable production at high speeds to 800 feet per minute. Because only one roll of each pair of cross rolls is driven, wear is reduced and roll life lengthened.



- DEPENDABLE SERVICE
- HIGH PRODUCTION
- QUALITY STRAIGHTENING

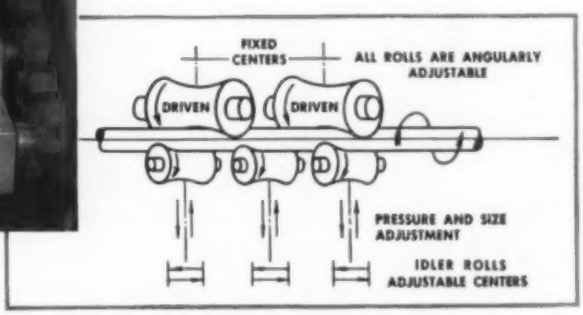


Photo and diagram of 5-roll design shows engineering principle of driven rolls with opposed idler rolls.

Ask for Bulletin No. 25

SUTTON Engineering COMPANY

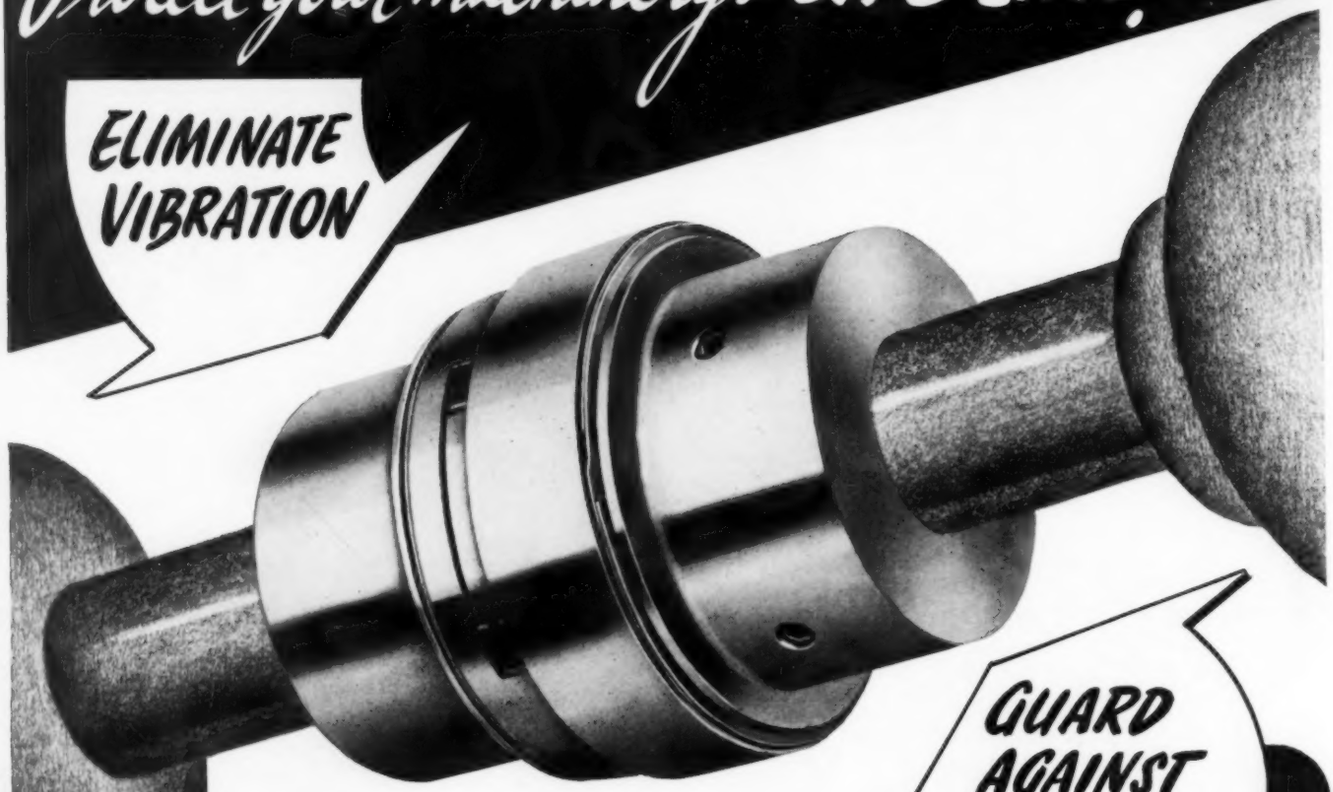
Manufacturers for Ferrous and Non-Ferrous Metal Industries

STRAIGHTENERS, EXTRUSION PRESSES, HYDRAULIC STRETCHERS, SHEET LEVELLERS, GAG PRESSES, ROTARY CLEANERS, HEAVY-DUTY UNIVERSAL JOINTS, ROLLS.

BELLEFONTE, PENNSYLVANIA

Protect your machinery's LIFE-LINE!

ELIMINATE VIBRATION



GUARD AGAINST LOAD SHOCK!

Specify LOVEJOY FLEXIBLE COUPLINGS

When you install Lovejoy Couplings, you guarantee your machinery the benefits of years of coupling design and engineering experience. You know that smooth, steady power transmission will keep your runout tables, conveyors, hoists, pumps and other production equipment operating at peak efficiency.

Note the compact, accurately machined bodies and jaws—the special cushioning materials—and you'll see why Lovejoy spells the end of your "down-time" worries... why misalignment, backlash, and surge are reduced to a bare minimum.

Lovejoy Couplings reduce maintenance time. Cushions are changed without shutdown. Lovejoy Couplings never require lubrication.

Write to us now for full technical data and engineering advice. Our illustrated catalog, with handy selector charts, is yours without obligation. Just forward your request.

LOVEJOY FLEXIBLE COUPLING COMPANY

4893 WEST LAKE STREET CHICAGO 44, ILLINOIS

Manufacturers of Couplings, Universal Joints and Variable Speed Transmissions

increased as a result of this rehabilitation program. Replacing obsolete equipment with new installations of modern design also will permit closer control of quality.

The over-all program, accomplished without any substantial loss of production, was commenced in 1948 with the construction of a coke oven battery of 38 ovens and the rehabilitation of an old battery of 69 ovens. Following that, a 65-oven battery was constructed after three old batteries had been demolished.

In the coal chemicals plant, facilities were rebuilt and new equipment was installed. Gas pumping and gas holder capacities were increased and facilities for cooling water were installed because of the increased temperature and lower volume of the Mahoning River.

A complete fire protection system was installed in the coke plant and a new building was erected to house the coke plant laboratory and offices.

Republic's Youngstown coke plant can produce about 3000 tons of coke from 4300 tons of coal daily.

BEGIN CONSTRUCTION OF ASSEMBLY PLANT

▲ Clark Equipment Co., manufacturers of industrial materials handling trucks, construction equipment and heavy automotive components, announced plans to erect a new plant on the outskirts of Benton Harbor, Mich.

Construction will start immediately on a 100-acre tract of land, and the plant is expected to be in operation before the end of 1954. The 145,000 sq ft building will be used as an assembly plant for a new line of tractor shovels to be produced by Clark and for the assembly of power shovels now made in the present Benton Harbor plant. The tractor shovels are the first new items of construction equipment developed by Clark since its acquisition of Michigan Power Shovel Co. last May.

DRAVO CORP. MOVES ATLANTA SALES OFFICE

▲ The Atlanta, Ga., office of Dravo Corp., under the supervision of William W. Timmis, Jr., has been moved to Room 361, 1401 Peachtree St., N. E.

AMERICAN CHEMICAL PAINT COMPANY

AMBLER CHEMICALS ACP PROCESSES PENNA.

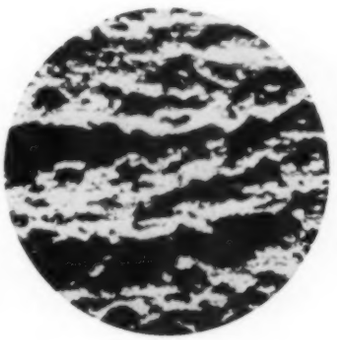
Technical Service Data Sheet

Subject: EFFICIENT PICKLING WITH RODINE®

ADVANTAGES OF "RODINE"

RODINE is used in sulfuric and muriatic acid baths for improved pickling and increased production. It meets Government Specification U.S.N. 51-I-2.

In straight line pickling of wire, rod and tubing, RODINE makes available more metal for drawing by protecting steel from acid attack. In batch pickling of sheet steel, RODINE improves the surface. In rapid, continuous strip pickling, RODINE not only saves acid and metal, but also prevents over-pickling during line shutdowns.



◀ *This steel surface was pickled in an uninhibited acid bath. Note the deep pits, and that the surface is visibly crystalline.*

This surface was pickled exactly like the one above except that "RODINE" was added to the acid solution. Only scale pockets and roll marks are visible; no pitting occurred. ▶

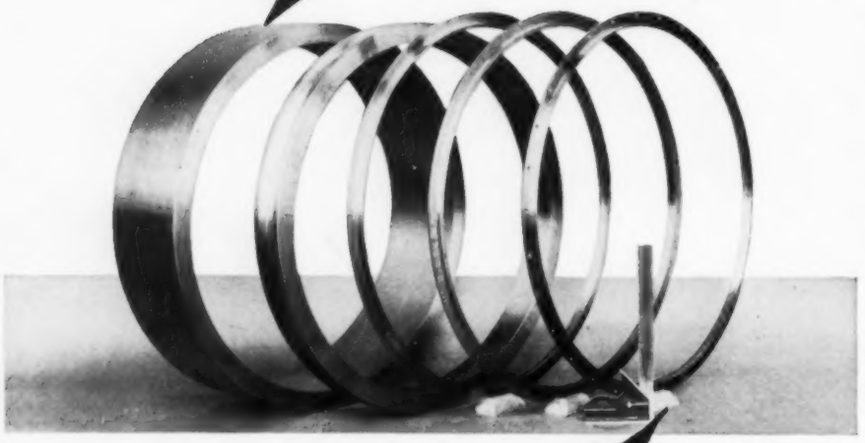
CHEMICALS ACP PROCESSES

WRITE FOR DESCRIPTIVE FOLDER ON "RODINE" AND INFORMATION ON YOUR OWN PICKLING PROBLEM.

CHEMICALS ACP PROCESSES

DURASPUN

CENTRIFUGALLY CAST by DURALOY



CUT and FINISHED by THE CUSTOMER

High Alloy rings for jet engines . . . we did the casting and rough finishing and the customer did the cutting and final finishing.

Centrifugally cast metal gives an exceptionally fine, dense, uniform grain structure. The strength of the metal approaches that imparted to a bar or ingot when it is hot forged. It produces an ideal metal for the tough service required of jet engine parts.

Incidentally, as evidence of our knowledge of and experience with tough alloy castings — static as well as centrifugal — the records show very few rejections by this engine manufacturer who subjected each of the many rings we furnished to his own very rigid tests.

May we suggest that you let Duraloy work on your high alloy castings — chrome iron, chrome nickel or nickel chrome? We have the experience and facilities for turning out high quality castings.

3-DU-9

THE DURALOY COMPANY

Office and Plant: Scottdale, Pa. • Eastern Office: 12 East 41st Street, New York 17, N.Y.

Detroit Office: 23906 Woodward Avenue • Pleasant Ridge, Mich.

Atlanta: J. M. TULL Metal & Supply Co. — Chicago: F. O. NELSON, 332 S. Michigan Avenue

METAL GOODS CORP.: Dallas • Denver • Houston • Kansas City • New Orleans • St. Louis • Tulsa

Wheeler M. Bearden, formerly of the Pittsburgh office, will join the Atlanta staff.

The Atlanta office handles the sales and services of Dravo's line of warm air space heaters consisting of oil and gas fired models and suspended gas fired units. This office also handles the sales of crane cab and steel mill pulpit air conditioners, pre-fabricated piping and construction services.

NEW TORRINGTON PLANT COMPLETED IN CANADA

▲ The Torrington Manufacturing Co., announced completion of a new Oakville, Ont., plant for its wholly-owned subsidiary, The Torrington Manufacturing Co. of Canada, Ltd.

Torrington, which operates a second subsidiary in Van Nuys, Calif., and recently completed a major expansion program at its home plant, manufactures more than 325 different types of air impellers for use in all types of heating, cooling and ventilating equipment.

LOCOMOTIVE REPAIR SHOP INSTALLED AT ERIE, PA.

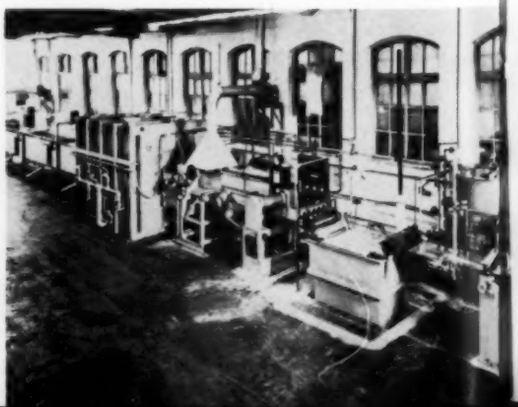
▲ A complete locomotive rebuilding and overhaul service has been established in Erie, Pa., by the General Electric Co. Locomotive and Car Equipment Department.

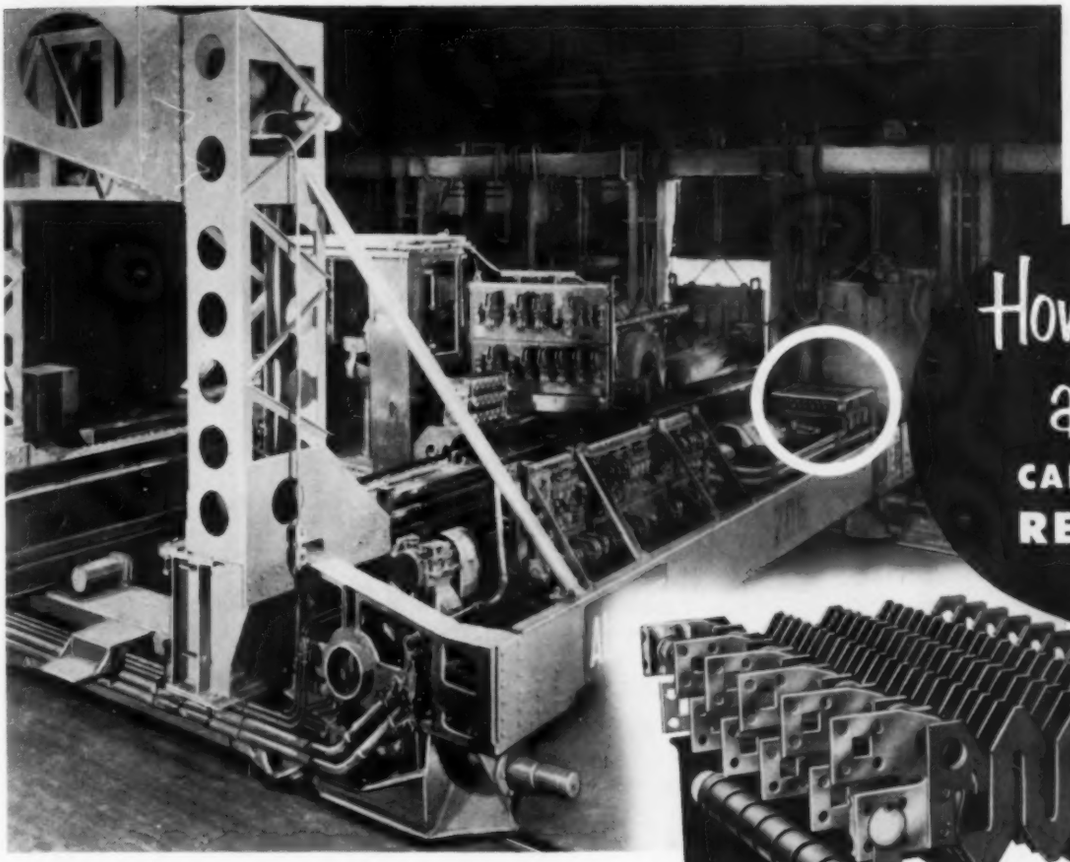
This new facility will be in addition to the service shop facilities currently available to users of locomotives throughout the U. S. General Electric maintains a network of 31 service shops throughout the country, all of which are engaged in the repair and modernization of transportation equipment.

The new service is being set up to

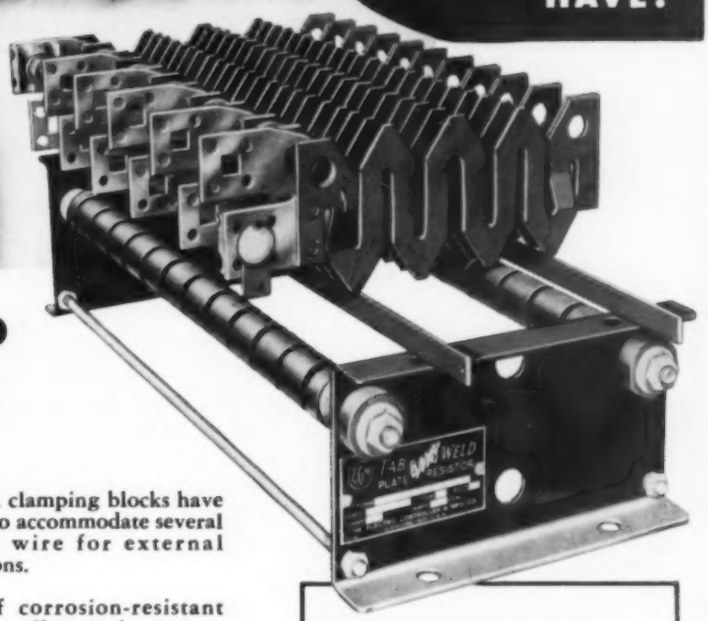
ANNEALING UNIT

Rodney Metals, Inc., New Bedford, Mass., operates this continuous annealing line to produce mirror-bright stainless steel strip in widths up to 25 in. and thicknesses as low as .002 in.





How many advantages CAN A RESISTOR HAVE!



ONLY EC&M TAB-WELD PLATE RESISTORS HAVE ALL THESE FEATURES!

1. Spot-welding of resistor ends, offset to bring adjacent grid eyes into intimate contact, results in permanent current-carrying path throughout the section.
2. No burning at grid eyes.
3. No periodic tightening of clamping nuts.
4. Terminal plates welded to resistor tabs along one side of section. Small adjustments in resistance value easily effected because plates are closely spaced.
5. No burning at taps.
6. Negligible resistance change between cold and maximum working temperature.
7. Insulating spacers of high dielectric strength accurately molded to shape from noncarbonizing material which remains dimensionally stable.
8. Terminal clamping blocks have grooves to accommodate several sizes of wire for external connections.
9. Made of corrosion-resistant chromium alloy steel.
10. Nonbreakable.
11. Double insulation to ground.
12. All standard sections same length, width and height.
13. Standard mill sections built with same size resistors per section.
14. Separate nuts on supporting rods clamp grid-stack independently of end-frame clamping. Accurate mounting-hole dimensions maintained regardless of variation of grid-stack length.

SHUTDOWN AVOIDED! Recently in one installation, a swinging overhead-crane load bumped resistors on charging machine and smashed end-frames and broke several spacers of grid assembly. *Shutdown was avoided* because current-carrying path of EC&M TAB-WELD Resistors remained intact and permitted charging of furnaces to continue. Later when down-time was available, section was replaced and returned to repair shop for new spacers and end-frames. This is another example of the durability of EC&M TAB-WELD Resistors.

Write today for illustrated Bulletin No. 942-B.

1806

THE ELECTRIC CONTROLLER & MFG. CO.
2698 EAST 79TH STREET • CLEVELAND 4, OHIO

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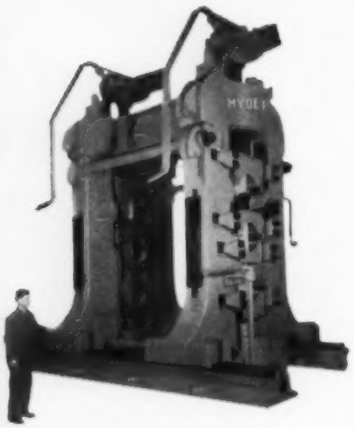
RED CIRCLE Rolls ALLOY-CHILLED

Rolling Mill Equipment

Outstanding in quality and in performance Hyde Park Rolling Mill Equipment has enjoyed the respect of the industry for more than fifty years.



Bar Mills
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Special Machinery
Machine Work

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FOUNDRY & MACHINE CO.
Hyde Park, Westmoreland County, Pa.
ROLLS
ROLLING MILL MACHINERY
GREY IRON CASTINGS

EXTRUSION PRESS CYLINDER MACHINED AT BETHLEHEM

Big forged steel main cylinder for 12,000-ton extrusion press is machined at the Bethlehem, Pa., plant of Bethlehem Steel Co. for shipment to United Engineering and Foundry Co. at Pittsburgh, Pa. After machining, the cylinder will be more than 22 ft long, have an outside diameter of approximately seven ft at the widest point and weigh 88 tons. As part of the Air Force heavy press program, the press will produce aircraft structural sections many times faster than present manufacturing methods permit.

fill a need for a complete locomotive rebuilding service among industrial locomotive users and those railroads operating comparatively small fleets of motive power.

The new program will include all kinds of heavy maintenance and overhaul rebuilding, modernization, conversion, and wreck rebuild work.

New locomotive warranties will be issued to operators of locomotives that are completely rebuilt by G. E. On locomotives, rebuilt or overhauled to customers' specifications, warranties will be issued to cover areas on which work was done.

SUBSIDIARY MERGES WITH OKONITE CO.

▲ The Okonite Company of Passaic, N. J., manufacturer of insulated wires and cables, announces that, effective April 1, The Okonite Callender Cable Co., Inc., its wholly-owned subsidiary, will be merged with the parent company. This corporate change will make possible the streamlining of certain operations and, at the same time, will eliminate the duplication of effort that was required while handling that manufacturing plant as a separate organization.

The Okonite-Callender plant was established in Paterson, N. J., in 1924 as a joint venture of The Okonite Co. and British Insulated Callender's Cables Ltd. of England. The half-interest of the British firm was purchased by Okonite in 1948. The trade-marks "Okonite-Callender" and "Okocal" will be retained to identify the paper-insulated power cables and splicing materials produced by the 500 employees in the manufacturing unit. There will be no change in personnel or products.

ANNOUNCE PURCHASE OF TWO COMPANIES

▲ Purchase of the George J. Hagan Co. by Salem-Brosius, Inc., was disclosed in a joint announcement. Both companies design, manufacture and sell furnaces and heat treating equipment but have sold their products to different industries.

A joint announcement by President R. E. Talley of the George J. Hagan Co. and President Ward A. Wickwire, Jr., of Salem-Brosius, Inc., said Salem-Brosius has bought all outstanding stock of the Hagan Co. for an undisclosed amount of cash and will operate that concern as a wholly-owned subsidiary.

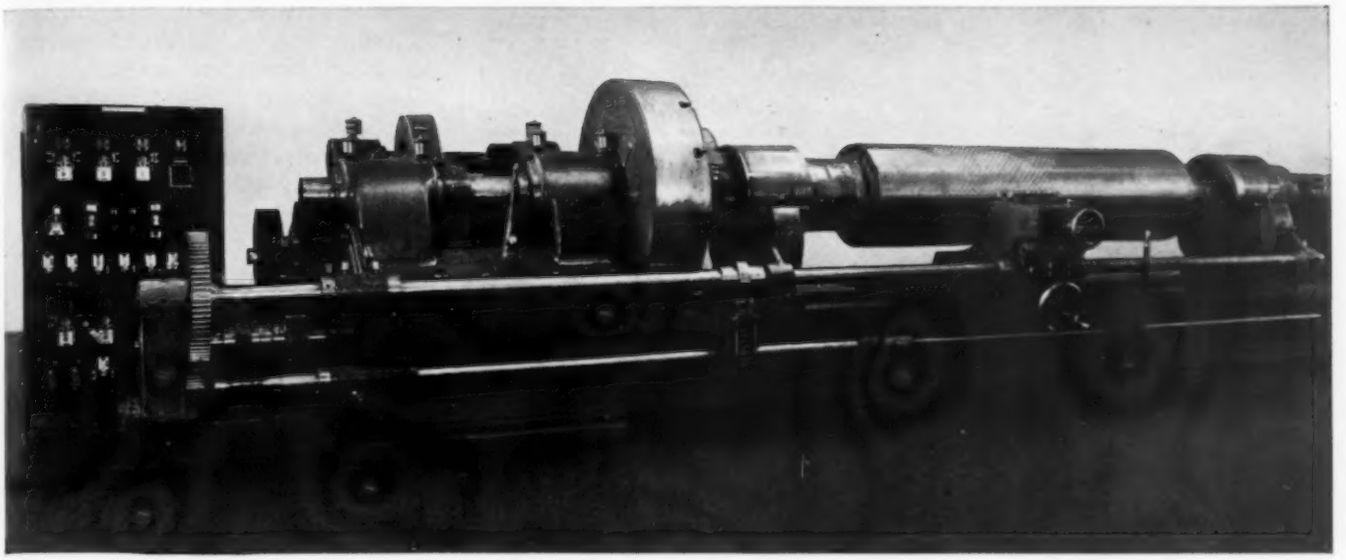
Personnel and policies of both companies will continue unchanged except that Mr. Talley will retire as president of the George J. Hagan Co. and Mr. Wickwire will assume the presidency of both companies.

The purchase of all interests held by H. L. Hall, of Toronto, Canada, in H. L. Hall Corp., Ltd., and the Holbeck Corp., Ltd., Toronto, Canada, was also announced. Both companies deal in heating, heat treating, and other types of industrial furnace equipment as well as industrial processing equipment and machinery.

Salem-Brosius will operate the

Engineered Rebuilding

How Simmons Methods Increase Machine Tool Output and Efficiency



REBUILT...REDESIGNED... ITS PRODUCTION TRIPLED

It used to take a manufacturer of steel floor plate 350 hours to groove the alloy rolls which made his plate. "Too slow," they said, and asked Simmons if they could convert a standard lathe to their special purpose. Here's how Simmons' engineers did it:

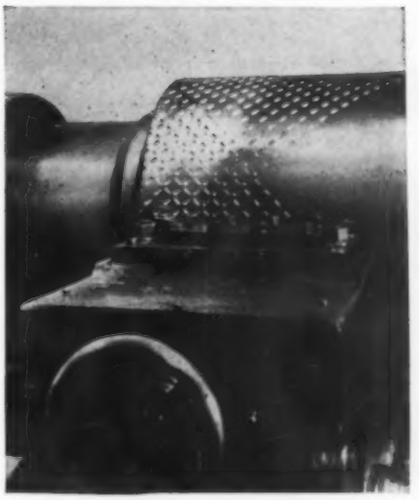
- **Rotation of the roll, traverse of carriage, and movement of carriage head were all synchronized, and all gears and clutches kept free of lost motion.**
- **Special gearing devised and built which maintains same groove spacing on rolls of varying diameter.**

In addition, the lathe was completely rebuilt—all sliding surfaces replaced... new bearings installed throughout... new motors and wiring.

The result? Average machining time was cut from 350 to 120 hours. Two thirds!

Rebuilding can get results like this for you, too. We'll rebuild and modernize your tools, or buy used ones and rebuild to your needs. Guaranteed performance—delivery within weeks.

Send us a list of your machine tools that might be rebuilt. We'll promptly quote price and delivery. Write, wire or phone today.



***Close-up of tool carriage** shows how rolls are grooved. The rolls are used in manufacture of steel safety floor plates.*

Simmons Machine Tool Corporation
Main Office and Plant:
1712 North Broadway, Albany 1, N. Y.

New York Office:
50 East 42nd St., New York, N. Y.

SIMMONS GIVES USED MACHINE TOOLS
A NEW LEASE ON LIFE

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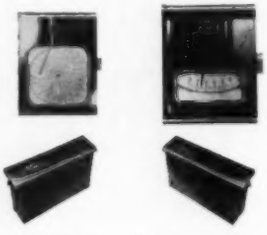
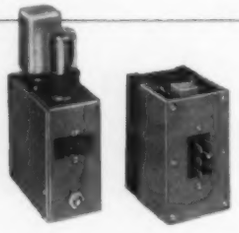
NOW! Brilliant new low-cost control systems use your existing wires to relay information between remote stations and central control panels. Femco equipment guards vital points in your process, eliminating constant attendance.

Femco REMOTE CONTROL AND CARRIER TELEMETERING

Measures, transmits and records operating data from one or more remote locations to a central control station. Efficient and economical. Uses existing power or telephone lines.





PUMP INDICATION SYSTEMS

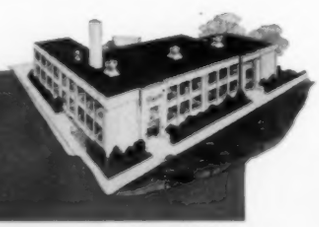
Watch remote pumps, valves, water or liquid levels and alarms. Use a single pair of wires to a centralized control point. Easy to install.

SIGNAL SYSTEMS

Send 25 controls or indications two-ways over a single pair of wires! Ideal for blast furnace wind control.

Industrial SIGNAL SYSTEMS can be engineered for many different applications. Radio frequency or audio tones, signal by means of horns, buzzers or lamps, or perform operations automatically.

Ask for YOUR Femco Data Kit



FARMERS ENGINEERING AND MANUFACTURING CO.
IRWIN, PENNSYLVANIA

Specialists in Electronic Communication and Control

companies as wholly-owned subsidiaries. Other than the retirement of Mr. Hall no personnel changes are anticipated.

GRANITE CITY EXPANSION NEARING COMPLETION

▲ All major projects have been completed in the expansion program of Granite City Steel Co., Granite City, Ill., according to The Rust Engineering Co., the general constructor.

The program, started in 1951, has now increased the mill's annual ingot production capacity from 700,000 to 1,200,000 ingot tons. It also has resulted in improvement and expansion of facilities for processing the additional ingot tonnage into flat-rolled steel products.

The current program gives Granite City Steel some of the most modern open hearth and rolling mill facilities in the industry, according to an official of the Rust firm, which constructed three new open hearth furnaces, a new 46-in. blooming mill, three new slab heating furnaces, and made alterations to the hot strip mill.

The scope of the contract included all foundation and building construction, erection and installation of all mill machinery, and all mechanical work necessary.

CONTRACTS PLACED FOR ORE DEVELOPMENT

▲ Caland Ore Co., Ltd., Inland Steel Co.'s Canadian mining subsidiary, have placed orders with Canadian manufacturers for more than $1,500,000 of electrical equipment that will be used in developing its ore property near Atikokan, Ontario.

Canadian General Electric Co., Ltd., and Canadian Westinghouse Co., Ltd., will supply the equipment to Construction Aggregates Corp. of Chicago, Ill., the company engaged by Caland to dredge the overburden from the ore body.

The order included six giant electric motors of 10,000 hp each, two of 1,000 hp, and several smaller motors. It also included equipment for a substation to step down the voltage from the 115,000-volt power line being built by the Hydro-Electric Power Commission of Ontario from Port Arthur to the mine site.

The motors will be used to power dredging operations. It is estimated

that 160,000,000 cubic yards of silt must be removed from the bottom of Falls Bay in Steep Rock Lake. This was reported to be the biggest dredging project ever contracted.

AIR POLLUTION MEETING SCHEDULED FOR MAY

▲ The 47th annual meeting of the Air Pollution Control Association will be held May 3, 4, 5, and 6 in Chattanooga, Tenn. Some 600 management executives and other representatives of the industries, research scientists, and air pollution control officials are expected to attend the four-day meeting.

Technical papers will be presented covering the subjects of coal, incineration, petroleum, municipal problems, dusts and fumes, steel, odors, measurements, and meteorology.

The Air Pollution Control Association, formerly known as the Smoke Prevention Association, was founded in 1907 to fill the need for a group specifically interested in air pollution and its control.

ANNOUNCE OPENING OF NEW SALES OFFICE

▲ The opening of a new sales office in New Orleans, La. at 256 Lee Circle Building, to service southern Miss. and La. was announced by Elliott Co., Jeannette, Pa. Its staff includes G. C. Bayles as manager, and C. W. Britt, Jr., both formerly in the company's Atlanta, Ga. office.

MAGNETIC DOMAIN STUDY CONDUCTED BY U. S. STEEL

▲ Scientists at U. S. Steel's research and development laboratory in Pittsburgh, Pa. are conducting an extensive study of magnetic domains in electrical steels, studying causes of energy losses in electric motor and transformer cores.

Modern electric motors and transformers have been brought to a high degree of efficiency through the use of silicon steels. These steels permit the necessary alternations of the magnetic field without undue energy losses. In addition, they possess increased electrical resistance which diminishes that part of the loss due to eddy currents. They also exhibit relatively little aging effect.

It is believed that certain magnetic

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now, an SKF improvement in the internal design of Spherical Roller Bearings provides

25% to 50% increased capacity
2 to 3½ times increased service life

Your SKF Distributor can *show* you why, when you replace a bearing with the SKF Type "C" Spherical Roller Bearing, you can expect it to *last* up to 3½ times longer, expect it to provide up to 50% increased capacity, than any other design available.

All the facts—engineering data, capacity and life comparisons, sizes available—are contained in SKF Bulletin No. 365-S. Ask your nearby SKF Distributor for a copy, or write direct to **SKF INDUSTRIES, INC.,** PHILADELPHIA 32, PA. —*manufacturers of* **SKF** *and* HESS-BRIGHT® *bearings.*

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BALL AND ROLLER BEARINGS

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At Foote Bros. you will find a complete line of enclosed helical and worm gear drives for every job. Ratios and capacities to answer every speed reduction need. Also available to assure long and satisfactory service is a complete line of Foote Bros.-Louis Allis Gearmotors, both vertical and horizontal.

Foote Bros. offers these advantages: Nearly 100 years of design, engineering and manufacturing experience—the latest in gear-cutting techniques—better control of materials. Modern production techniques at three large plants assure superior drives for every power transmission requirement.

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Chicago 9, Illinois

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Company.....

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Position.....

City.....*Zone*.....*State*.....

domain orientations might further improve the directional properties of grain-oriented steels. The present research into magnetic domains is to determine their characteristics and possibly to discover ways to control their orientation.

ANNOUNCE FORMATION OF NEW DIVISION

▲ Sintering Machinery Corp., Netcong, N. J., announces the formation of a new division to devote its efforts to the design, construction and sale of ore beneficiation plants and related process equipment. Operating under Dwight-Lloyd, Inc., the new company takes its name from the inventors of the sintering process who also founded Sintering Machinery Corp.

The current research program of Dwight-Lloyd has resulted in the development of new equipment and processes for the economical treatment of taconite and other low grade ores.

LETOURNEAU DISPLAYS SEMISPHERE BUILDING

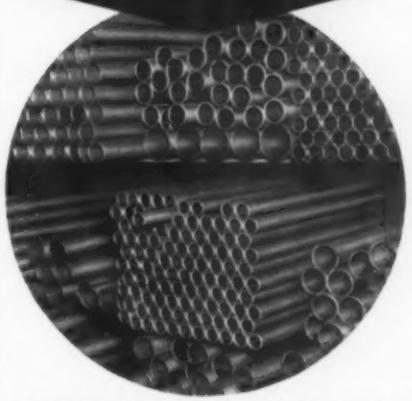
▲ There are 3,289,402 cu ft of enclosed space and 70,686 sq ft of floor area in a huge new dome-shaped building just completed at Longview, Tex. There are no interior structural supports in this 85-ft-high, 300-ft-diameter building, and all of the assembly work to create it out of aluminum and steel was accomplished at ground level. This spacious structure, the LeTourneau Semisphere Building, is a product of R. G. LeTourneau, Inc., and was built adjacent to the LeTourneau Longview plant and corporation headquarters.

Similar buildings can be erected anywhere else in the world by shipping the prepared metal parts to the site. These new structures provide weather-tight floor space and cubic capacity at far less cost than conventional methods of construction, and they can be erected quickly by semi-skilled labor.

Inquiries already received by LeTourneau from people and firms planning new buildings demonstrate the wide appeal for this type of structure. LeTourneau Semisphere Buildings are being considered for many functions, including the following: merchandise warehouses, freight handling centers, heavy equipment display or storage, agricultural bulk products storage, automotive display, manufacturing and assembly line operations, aircraft hangars, commercial and civic entertainment, religious gatherings, and indoor athletic facilities. Completely erected, the building will sell at less than $4 per sq ft of space afforded.

The interior of the LeTourneau Semisphere building, product of R. G. LeTourneau, Inc., Longview, Texas. The relative sizes of the automobiles and their drivers give some idea of the vast amount of unobstructed interior space in the dome-shaped structure. Concentric rings of acoustical material have been suspended from the ceiling of the dome for sound control. Near the top of the 85-ft center pole is a lighting installation of 75,000 watts. As many as 12,000 persons can be accommodated at a function held in this 70,686-sq ft building which has a diameter of 300 ft.

THREE EPOCH-MAKING New Yoder DEVELOPMENTS give Big Boost to



ELECTRIC-WELD TUBE MANUFACTURE

1 For high-speed, low-cost production of tubing from aluminum, nickel, brass and other non-ferrous metals and alloys: Revolutionary new high-frequency electric induction process for cold-forming and welding coiled strip into tubing, *without drawing* or *heat treating*. Welding speeds from 30 to 120 fpm.—almost as fast as electric-weld steel tube making. *The lighter the gauge, the higher the speed and lower the cost, all the way down to .025".*

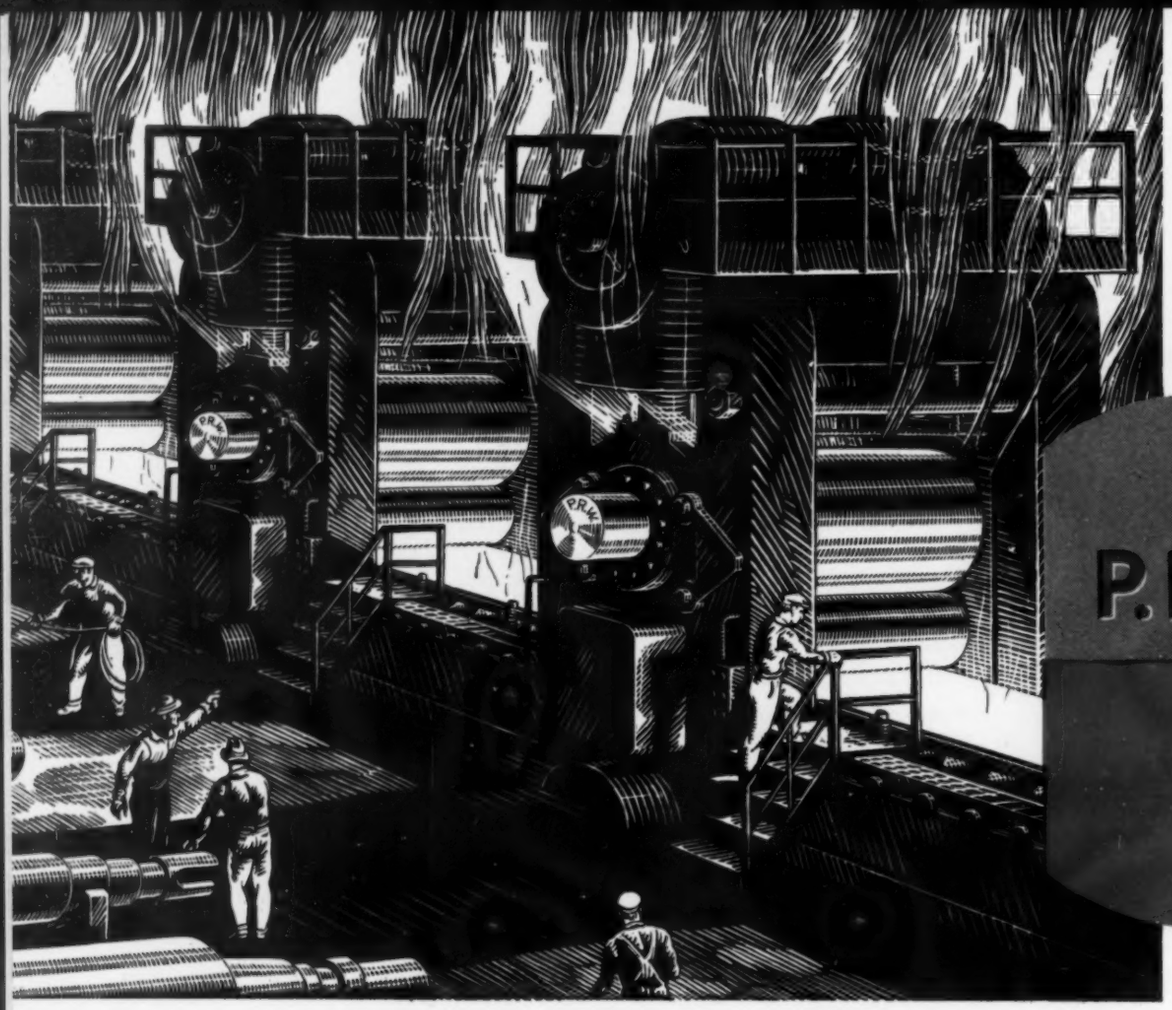
2 New Induction-Weld Mill for making STEEL tubing up to 4" dia. and merchant pipe up to 2" dia. Speeds up to 250 fpm.—almost double that of resistance welding.

3 New 4-in-1 Resistance Tube Welder—actually four small transformers built into the most compact, efficient, trouble-free unit ever designed for tube welding. Insures highest daily production of quality tubes, with minimum scrap losses.

All three developments are Yoder "Firsts"—making cold process tube manufacture more attractive than ever. For complete information and literature, write, phone, or wire.

THE YODER COMPANY
5495 Walworth Ave., Cleveland, Ohio

ENGINEERING YODER MANUFACTURING



Our rolls are color marked for specific applications

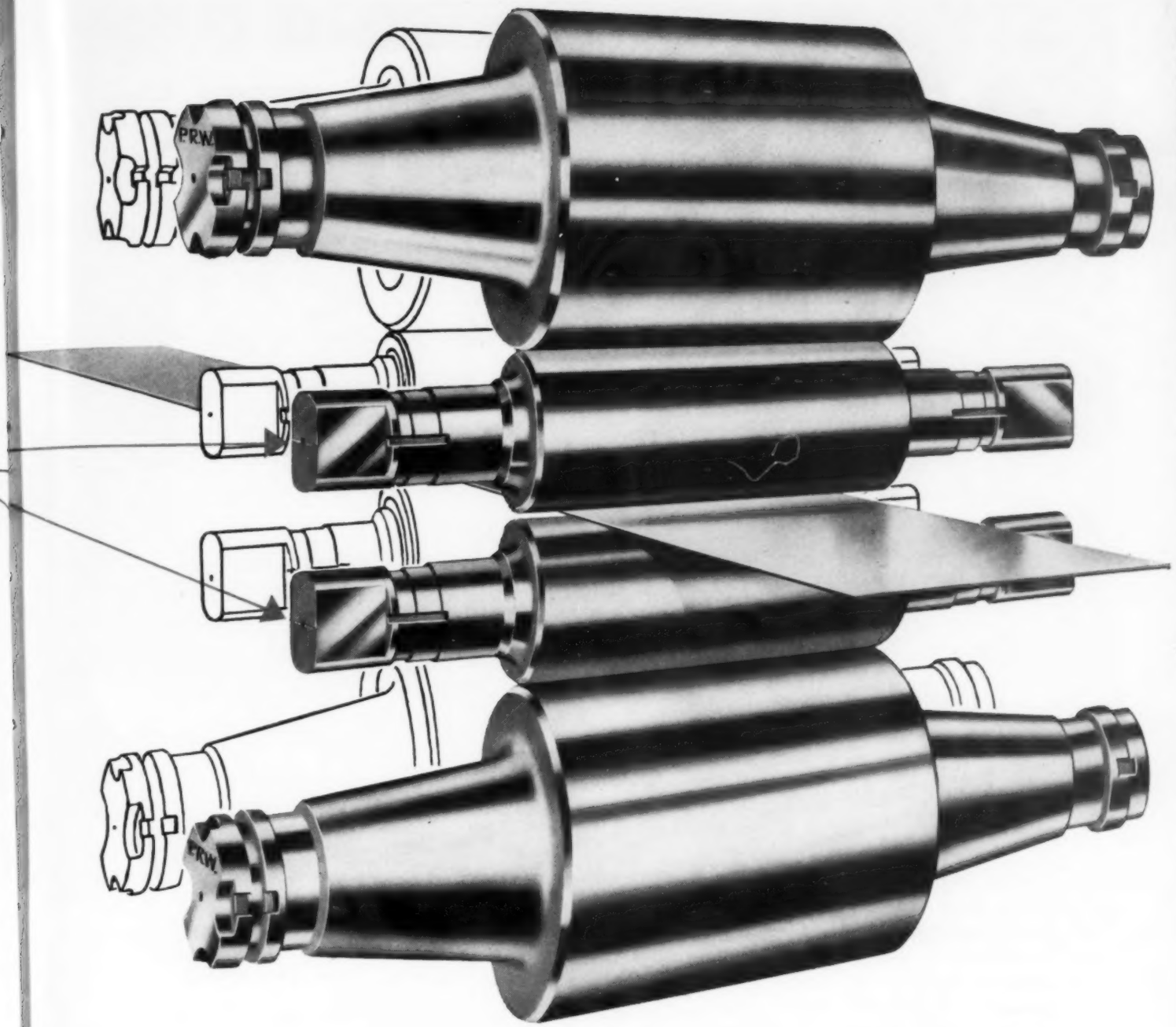
P.R.W.

"the right roll in the right stand"

...produces more tonnage at less cost

Pittsburgh roll engineers . . . who combine years of practical experience with technical know-how . . . can help you in selecting the *right* roll for *each* application in your mill.

BLAW-KNOX



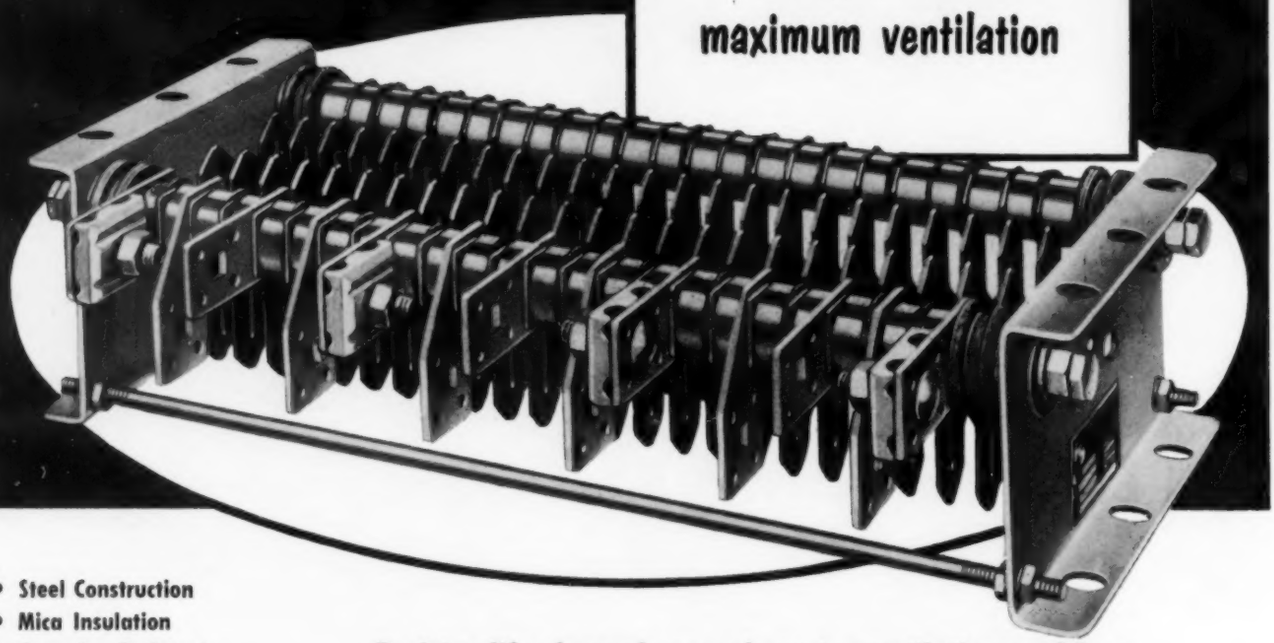
PITTSBURGH ROLLS

Chill • Sand • Moly Chill • Special Rail Finishing • Phoenix "K" • Sandaloy • Pittsburgh 25 • Pittsburgh 35 Pittsburgh 45 • Pittsburgh 55 • Pittsburgh Special Process • Phoenix 25 Phoenix 35 • Phoenix 45 • Phoenix 55 • Phoenix Special Process Phoenixloy • Phoenix Metal • Phoenix Metal Special • Phoenix Metal "F" Phoenix Metal Master • Carbon Steel • Phoenix "A" • Phoenix "A" Special • Piroco • Piroco "A" • Piroco "B" • Piroco Special • Herculyte

BLAW-KNOX COMPANY • ROLLS DIVISION • PITTSBURGH ROLLS DEPARTMENT
PITTSBURGH 1, PENNSYLVANIA

Resistor life depends on adequate ventilation.....

Patented P-G Grid Design assures maximum ventilation



- Steel Construction
- Mica Insulation
- Corrosion Resistant
- Vibration Proof
- Moisture Resistant
- Provision for Expansion
- Adequate Ventilation
- Rugged Terminals

Write for Bulletin No. 500

Resistor life depends on adequate ventilation and how efficiently heat may be dissipated . . . P-G grid design equalizes the amount of air space surrounding each leg or loop to obtain even heat throughout the grid area. (Note illustration.) . . . Since heat is rapidly and evenly dissipated, hot spots fail to develop and longer resistor life is assured . . . For a nonbreakable resistor (only steel and mica used) specify P-G on your next application.

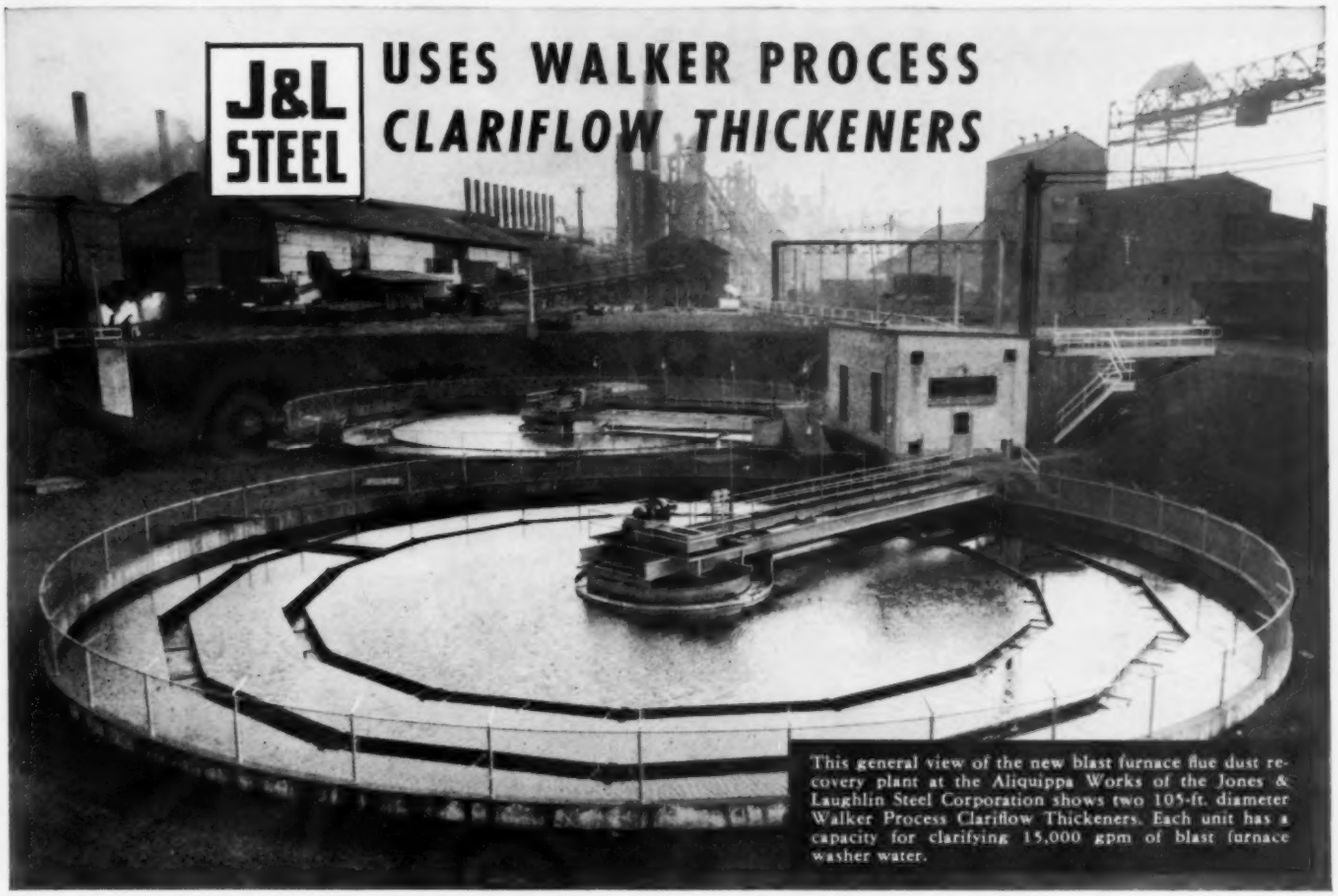
P-G

The Nonbreakable Steel Grid Resistor

THE POST-GLOVER ELECTRIC COMPANY

• ESTABLISHED 1892 •

221 WEST THIRD STREET, CINCINNATI 2, OHIO



This general view of the new blast furnace flue dust recovery plant at the Aliquippa Works of the Jones & Laughlin Steel Corporation shows two 105-ft. diameter Walker Process Clariflow Thickeners. Each unit has a capacity for clarifying 15,000 gpm of blast furnace washer water.

NEW BLAST FURNACE FLUE DUST RECOVERY PLANT

Removes Over 95% of Settleable Solids!

Single stage thickeners used

Two single stage Clariflow Thickeners were used in the Jones & Laughlin Steel Corporation Aliquippa Works for the following three jobs: (1) to remove over 95% of the settleable solids, (2) clarify the flow to less than five grains and (3) to thicken "mud" to within 40-50% for filtration.

Thickeners have inlet diffusers

The Clariflow Thickener is constructed for rugged use and is capable of overloading without work stoppage. It is provided with a multiple tangential inlet diffuser so that the flow of material entering the unit is uniformly diffused in a rotating manner.

"Short circuiting" at inlet prevented

Balanced rotation at the inlet of the Clariflow Thickener prevents short circuiting and the multiple weir troughs spaced over the entire rise area insure uniform slow rise to the surface of the water being clarified. This assures a clarified overflow containing the least amount of solids.

WRITE FOR BULLETIN 10I69

WALKER PROCESS

CLARIFLOW

thickeners

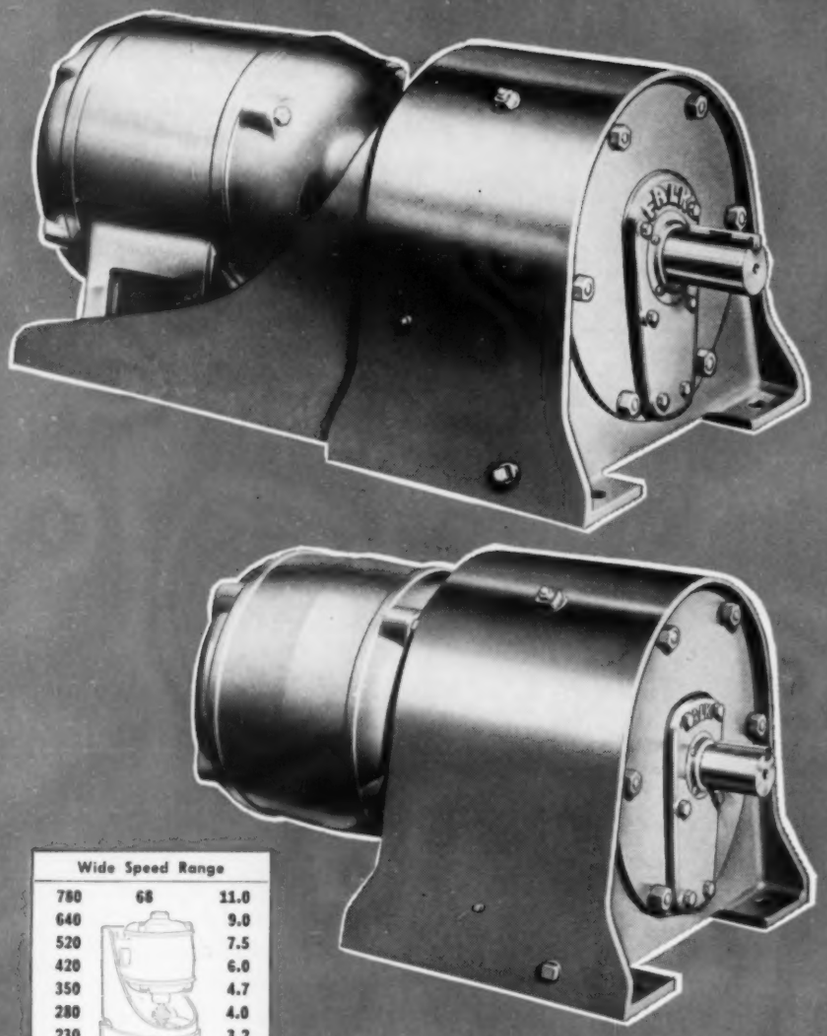
WALKER PROCESS WALKER PROCESS EQUIPMENT INC.
FACTORY • ENGINEERING OFFICES • LABORATORIES
AURORA • ILLINOIS

Both... All-Motor and Integral

ALL-STEEL FALK Motoreducers

use *complete* motors with *no* modifications

...another important reason why you should consult FALK!

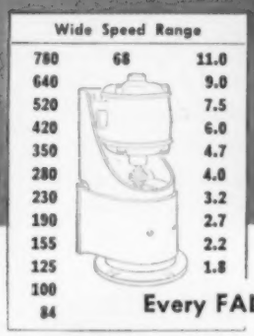


You never have the annoying problem of motor modification when you standardize on *all-steel* FALK Motoreducers. Both the universally popular All-Motor type and the newly redesigned Integral type use *completely standard motors without modification.* The motor can be quickly and easily replaced by another standard motor of any make, type or speed within the unit's AGMA rating when necessary without disturbing the reducing unit.

Many users choose the All-Motor type because it permits easy interchange of motors, *or even parts,* on the job, *in minutes*—and because reducer units and/or motors may be readily transferred from one line or plant location to another. Other users select the new Integral type with standard D-flange NEMA motor because it is a highly compact, streamlined unit providing the utmost in space economy.

In every FALK Motoreducer—All-Motor or Integral—the output speed (ratio) can be changed within the unit's torque capacity without modifying the motor.

Both types give you all the quality, adaptability, dependability and long-range economy for which FALK has been celebrated for more than sixty years. FALK Motoreducers are available from factory, field or distributor stocks throughout the country. Write to Department 247.



Every FALK Motoreducer has these "In-built" Factors—

Wide Speed Range. Selective ratio combinations provide output speeds from 1.5 rpm to 1430 rpm with stock gears.

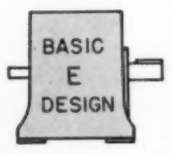
Sealed Housings. Dual closures and one-way vents keep oil *in,* dust and moisture *out.* Units are splash-proof, leakproof, dustproof.

Precision Gearing. Heat treated alloy steel, precision cut and shaved helical gearing throughout . . . quiet-operating crown shaved pinions . . . taper bored gears for easy ratio changes.

All-steel Housings. Unbreakable, strong, rigid. Generous overhung load capacities provided by wide bearing spans, large shafts and bearings.

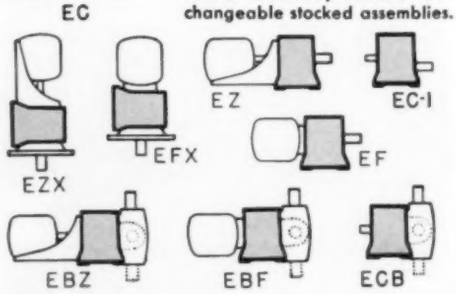
Streamlined inside and outside. Smooth, clean surfaces; machine welded construction conforms to NEMA motor frames.

Positive Lubrication. Large sump capacity . . . oil-tight construction assures clean lubricant . . . direct dip of revolving elements provides positive lubrication at all speeds.



EC

The basic E design permits maximum use of standardized parts . . . closer control over materials, processing, inspection and assembly . . . resulting in faster delivery from interchangeable stocked assemblies.



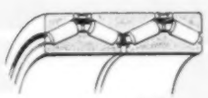
FALK ...a good name in industry

THE FALK CORPORATION 3001 W. Canal St. Milwaukee 8, Wis.

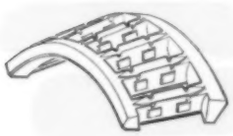
WRITE TO DEPARTMENT 247

Here's why **TORRINGTON** work roll bearings establish rolling mill records

Highest quality electric furnace alloy steels are used—carburized and heat treated to provide toughness, hardness, stability and uniformity.



Torrington Work Roll Bearings are designed and built with high thrust capacity to give better service under actual operating conditions.



One-piece cast-bronze cages with machined pads in each roller pocket reduce wear, lengthen bearing life and improve performance.

Accuracy in workmanship is characteristic of all TORRINGTON Bearings. This means a lower cost per ton of your finished product.

Many sizes of TORRINGTON WORK ROLL Bearings are available from stock for immediate shipment.

TORRINGTON WORK ROLL Bearings—both two-row and four-row types—are standard in a wide variety of sizes.

For lower operating costs, greater rolling efficiency, less down time...specify TORRINGTON!

TORRINGTON BEARINGS

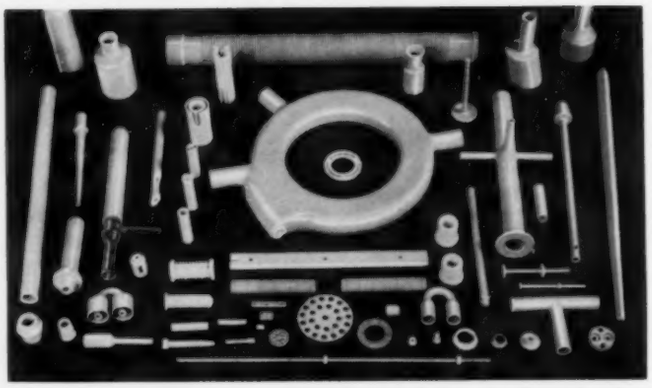
Spherical Roller • Tapered Roller • Cylindrical Roller • Needle • Ball • Needle Rollers

Superior
BLAST FURNACE COPPER CASTINGS

Cooling Plates of all kinds including Heavy Nose Super Cooled Bosh Plates.
Hot Blast Valves and Valve Seats
Blast Furnace Tuyeres. Licensed Manufacturers of all Leading Designs

SMEETH-HARWOOD COMPANY
8524 Vincennes Ave., Chicago 20, Ill.
In Canada—The William Kennedy & Sons, Ltd., Owen Sound, Ontario

Blast Furnace Copper Castings—also Brass and Bronze Mill Castings



HIGH TEMPERATURE PORCELAIN
SPECIALTIES

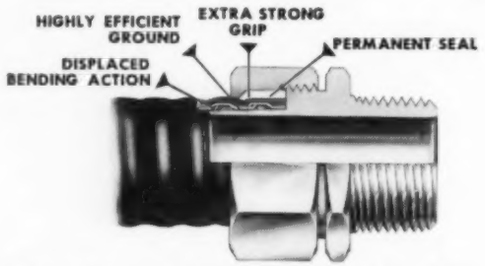
We are equipped to design and manufacture special porcelain products to do specific jobs. A few of the various shapes and sizes are shown above. On any of your porcelain requirements, a call to McDanel will save time and money.

Write today for our new catalog.

McDANEL *Industrial* PORCELAINS
McDANEL REFRACTORY PORCELAIN CO.
BEAVER FALLS, PENNA.

GRINDING BALL...MILL LINING BRICK...
MILL HEAD ASSEMBLIES...TANK & DRYER LININGS

it's new— an improved connector for liquid-tight flexible conduit (Sealtite or equivalent products)



PYLE-NATIONAL

"CT" series Connectors offer all these advantages

EXTRA STRONG GRIP
- Compression force applied against body shank—not against the conduit alone, making a vise-like clamp.
- Plastic-to-plastic grip with the conduit sheath avoids cutting and abrasion

PERMANENT SEAL
- Plastic Sleeve and Conduit Sheath have equal physical characteristics. The seal will last the life of the conduit.

HIGHLY EFFICIENT GROUND
- Less than 10 millivolt drop.

DISPLACED BENDING ACTION
- Tapered body shank extends beyond gland nut, preventing short radius bends, lengthening life of conduit sheath and permanency of joint.

"CT" series connectors can be installed assembled. Available in Straight, 45° and 90° types for ⅜" to 2" conduit. Meet U/L and J.I.C. standards.

SINCE 1897
THE PYLE-NATIONAL COMPANY
1383 North Kostner Avenue Chicago 51, Illinois

"Sali" Bushings

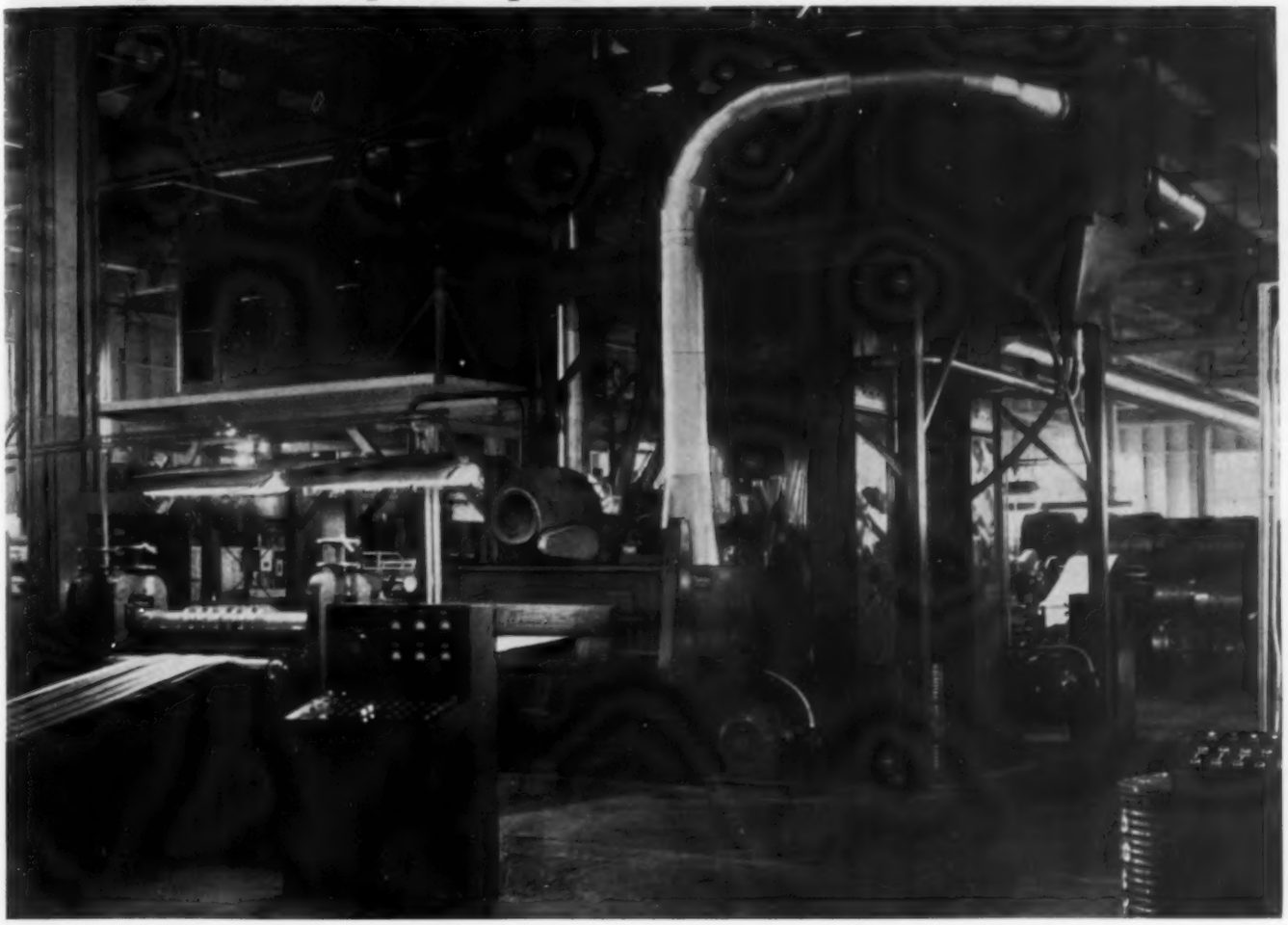
insulate!...

Eliminate grounds and shorts. Strong, resilient, phenolic material. Precision machined with undercut shoulders and clean NEMA threads for easiest, fastest installation.

UL

THE ADALET MANUFACTURING CO.
14300 LORAIN AVE.
CLEVELAND 11, OHIO

pioneering developments keep WHEELABRATOR® first in blast cleaning



Descaling Hot Rolled Steel Strip at Greatly Reduced Cost

Wheelabrator Descaling extends the economies of hot rolled strip to many new applications

If you are manufacturing a product which requires scale-free flat steel within the gage limits of hot rolled strip, Wheelabrator airless abrasive blast cleaning can save you many thousands of dollars annually. With a Wheelabrator, scale is uniformly and economically removed leaving a surface ideal for cold rolling, cold forming, cold drawing, and final finishing such as painting or galvanizing.

A typical application is at the Rome Cable Corp., Torrance, Cal., as illustrated above. Wheelabrator descaling provided them with these advantages over operating with pickled and oiled strip as purchased from the mills:

1. Operating in conjunction with a slitter line, Wheelabrating adds a cost of about $1.00 per ton to the cost of slit strip.
2. Being automatically controlled, it is operated by same labor required for a normal slitter line.
3. Saves many sq. feet of floor space as compared to a pickle line.
4. Surface provided is unexcelled for forming, welding and finishing heavy wall conduit.
5. All scale and the abrasive used to remove it are reclaimed as scrap.
6. Wheelabrating can be operated next to any equipment without contamination or corrosion of the equipment.

Many other applications of the Wheelabrator descaling process have shown equal benefits at reduced costs derived from the elimination of pickling, labor reductions and increased production. Write today for complete information on what the Wheelabrator can do for you.

Bulletin 894 describes the descaling of Steel Strip and Bulletin 914 describes the descaling of steel sheets. Send for your copies today.

American
WHEELABRATOR & EQUIPMENT CORP.
396 S. Byrkit St., Mishawaka, Ind.

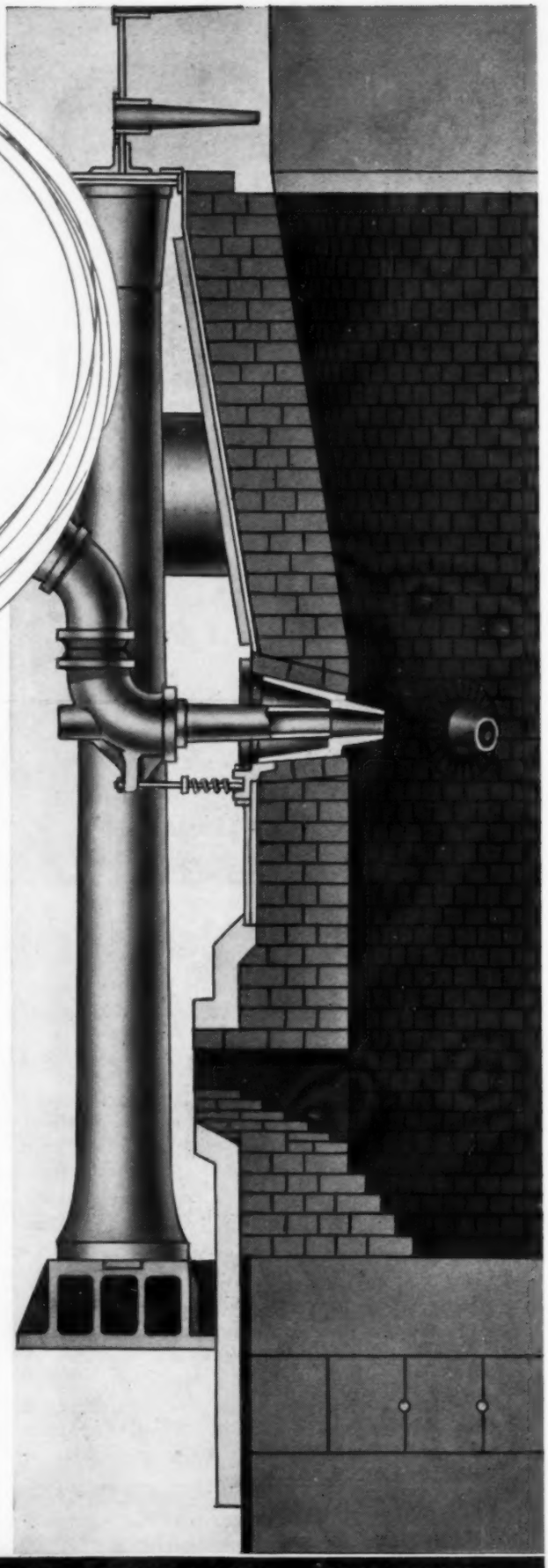
Wheelabrator®
AIRLESS BLAST CLEANING

SAVE ALL THE WAY WITH

NATIONAL

TRADE-MARK

CARBON BLAST FURNACE LININGS



Record operating economies — so outstandingly established by "National" carbon in blast furnace hearths—*needn't stop there!* Now you can get the same advantages — longer life, lower maintenance, smoother operation—with carbon linings in blast furnace walls, in tuyere and in bosch sections.

Present day economics indicate now, more than ever, a need for carbon "all the way". Let's talk it over in terms of *your* operation!

The term "National" is a registered trade-mark of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N. Y.

District Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

OTHER* NATIONAL CARBON *PRODUCTS:

ELECTRIC FURNACE ELECTRODES · CARBON BRICK AND RAMMING PASTE · TROUGH LINERS · MOLDS AND MOLD PLUGS · SKIMMER BLOCKS · SPLASH PLATES · TANK LININGS AND HEATERS · HEAT EXCHANGERS AND PUMPS · BRUSHES FOR MOTORS AND GENERATORS

Personnel News...

Arthur B. Glover was appointed superintendent of the electrical division of the Riverdale, Ill. plant of Acme Steel Co. Mr. Glover, formerly assistant superintendent of the electrical division, replaces **John H. Wagner** who recently retired. **Milton D. Robinson** was appointed assistant superintendent of the electrical division. Mr. Glover joined Acme Steel 25 years ago after serving in electrical engineering positions with General Electric Co., and with Union Electric Light and Power Co. Mr. Robinson joined the company in 1951. He previously served as a project engineer with the Gary Sheet and Tin Division of U. S. Steel Corp., and later as a self-employed consulting engineer.

A. B. Drastrup has been elected executive vice president of the A. M. Byers Co. Mr. Drastrup became associated with Byers in 1931, and has had broad experience in virtually all of the company's operations. Since 1946 he has been manager of steel sales. Three years ago he was also named assistant to the president. The elections of **J. F. Byers, Jr.** and **B. M. Byers** as vice presidents of the company also were announced.

H. J. Kalberkamp has been appointed chief engineer of Mesta Machine Co. Mr. Kalberkamp has been associated with Mesta for 28 years starting his career in 1926 as a machine designer of heavy steel mill equipment. He has served most recently in the position of division engineer of the proposal department.

Frans Wethly was named executive vice president of the Wilputte Coke Oven Division, Allied Chemical & Dye Corp. He succeeds **David M. Griffith** who has retired, but will continue association with the company as a consultant. Mr. Wethly has been active in the coke oven construction business for more than 30 years. He supervised the design and construction of by-product coke ovens in England, and has been responsible for the design and construction of many by-product coke oven plants in numerous countries throughout the world.

James H. Kunkle has been appointed superintendent of Republic Steel Corp.'s Warren, Ohio district coke plant. Mr. Kunkle was formerly superintendent of Republic's Troy, N. Y., coke plant. He was associated with the Koppers Co. for nine years as chief operating engineer before joining Republic in Troy in 1951.

Paul Carnahan was appointed vice president and assistant to the president, Great Lakes Steel Corp. Mr. Carnahan entered the operating department of Great Lakes Steel Corp. in 1933. He rose to the position of director of production and then became vice president in charge of sales which was the position he held immediately prior to the present appointment. **Albert C. Childs** was named vice president and general manager of sales. Mr. Childs began service in the sales department of Weirton Steel Co. in 1919. During his career, Mr. Childs has been manager of the New York and Detroit sales offices and since 1949 has been assistant vice president in charge of sales for Weirton Steel. **Elmer A. Schwartz** was named general manager of operations. Mr. Schwartz's career in the steel industry covers a period of more than 30 years during which he has served in various executive capacities with other steel companies. **Harry C. Burton** was named director of industrial relations. He was first employed in the Great Lakes accounting department in 1934 and transferred to the industrial relations department in 1946. He has been assistant director of industrial relations since 1947. **David M. Moon** who has been appointed director of personnel relations, joined Great Lakes in 1933 and became employment manager in 1940. He has been assistant director of personnel relations since 1944.

Edward E. Bauer has been appointed superintendent of regulator manufacturing for the General Electric Co.'s power transformer department at Pittsfield, Mass. In his new position, Mr. Bauer will be responsible for the manufacture of feeder voltage regulators of both induction and step types, including inductrols and inductrol power packs.

Edward J. Charlton, manager of development engineering, will become manager of fabrication at the Lukenweld Division, Lukens Steel Co. **Frank C. Kardevan** will join the Lukens field sales organization in the position of a field sales engineer to work particu-

ARTHUR B. GLOVER

MILTON D. ROBINSON

A. B. DRASTRUP

H. J. KALBERKAMP

larly with Lukenweld products. **William H. Funk,** assistant manager of development engineering, will become acting manager of the new products development department.

E. W. McNeill has been appointed vice president in charge of Ohio Seamless Tube Division of Copperweld Steel Co. Mr. McNeill succeeds **W. C. Connelly** who has retired.

Edward E. Christopher has been appointed district sales manager of the New York office of General Refractories Co. He was formerly head of the district sales office in St. Louis, Mo. **Thomas A. Fallon** was named to succeed Mr. Christopher as sales manager of the St. Louis office. In addition **Ward M. Trautman** has been named district sales manager of the Pittsburgh, Pa. office.

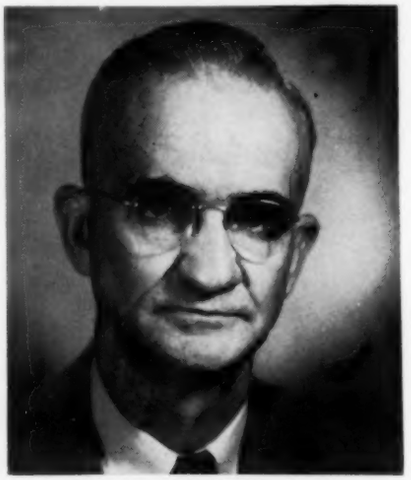
G. K. Lowe, W. C. Pittman and **L. R. Burke** were appointed district sales managers of the Charles Taylor Sons Co. Mr. Lowe will have charge of the territory comprising northern Ohio, western N. Y. and northwestern Pa. Mr. Pittman's district consists of southern Ohio and parts of W. Va. and Ind. Mr. Burke will have as his district western Pa., eastern Ohio and northern W. Va.

C. L. Peterson was appointed divisional vice president of the Brown Instruments Division of Minneapolis-Honeywell Regulator Co. and **O. B. Wilson** was named general sales manager. Mr. Peterson will devote the major part of his time to sales policy matters and long-range planning. In addition, he will assist in carrying out managerial duties at the policy-making level. Mr. Wilson will assume active administration of the entire divisional sales department.

Walter J. Assel, chief engineer, Steel and Tube Division, the Timken Roller Bearing Co., will retire from the company effective March 1. Prior to joining the

WALTER J. ASSEL

company in 1925, Mr. Assel had worked for the American Rolling Mill Co., Republic Steel Corp. and the Minnesota Steel Co. He is recognized in the Minnesota Steel Co. He is recognized in the tube industry the world over for his development of the Assel Mill, used for reducing and elongating tubes. Succeeding



RUBERT CAPLEY

Mr. Assel as chief engineer is **Rubert Capley.** Mr. Capley came to Timken in 1928 from Bethlehem Steel Corp.

C. A. Suchan, Jr. has been appointed New York district manager of Buffalo Steel Division, H. K. Porter Co., Inc. In his new position, Mr. Suchan will handle sales of all Buffalo Steel products in the New York territory. Previous to his present promotion, he had been on the company's sales staff at the home office for the past year.

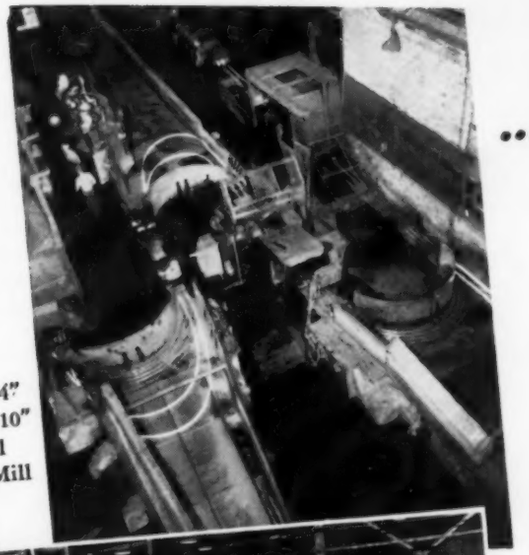
J. G. Squibb was appointed general manager of the Beech Bottom works of Wheeling Steel Corp., and **R. E. Bevington** was named assistant general manager.

Thomas H. Pattison has been appointed superintendent of operations at the Garrison plant, Pittsburgh, Pa., of Mackintosh-Hemphill Co. Associated with the company since 1920, Mr. Pattison has been plant metallurgist since 1937.

Alfred J. Porter has been elected a vice president of Heppenstall Co. Formerly manager of the company's Bridgeport, Conn., plant, Mr. Porter joined Heppenstall in 1914 as a part-time laborer in the forge shop. He served successively as night superintendent of the forge shop, superintendent of heat treating, production manager, salesman, sales manager, and manager.

Martin J. Hartigan has been appointed manager of supply purchases of Joseph T. Ryerson & Son, Inc. With headquarters in Chicago, Ill., he will coordinate all activities and responsibilities in connection with the purchase of plant and office supplies for the nationwide group of sixteen Ryerson steel service plants.

Charles F. Johnson, assistant secretary and city sales manager for Kropp Forge Co., has retired after 32 years with the firm. Mr. Johnson has been associated with the Chicago steel industry for the past 61 years. He began his career with the S. D. Kimbark Co. in 1893



View of 14" —12"—10" Mild Steel Rod Mill

...When it's tonnage that counts

depend on

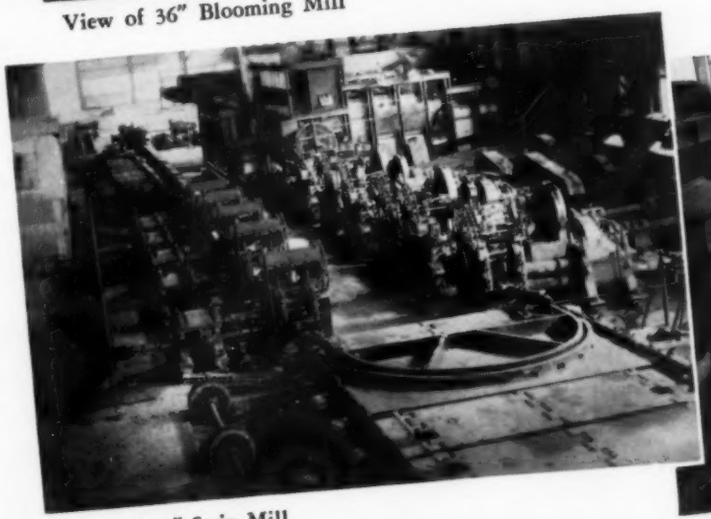
BIRDSBORO

STEEL MILL MACHINERY

For producing Blooms, Billets, Rod, Strip and Merchant Bar.

Birdsboro engineering skill makes possible modern equipment like this that you'll find in leading mills mass-producing billets, rod, sheet, strip, plate and other products to meet today's critical demands. Whenever you find it necessary to modernize your present equipment or add to your facilities—it may be this year or the next—Birdsboro engineers will be glad to work with you on your individual problems.

View of 36" Blooming Mill



View of 10" Strip Mill

View of Merchant Mill

BIRDSBORO

STEEL FOUNDRY & MACHINE CO.

Birdsboro, Penna.

Offices in: Birdsboro, Pa. and Pittsburgh, Pa.

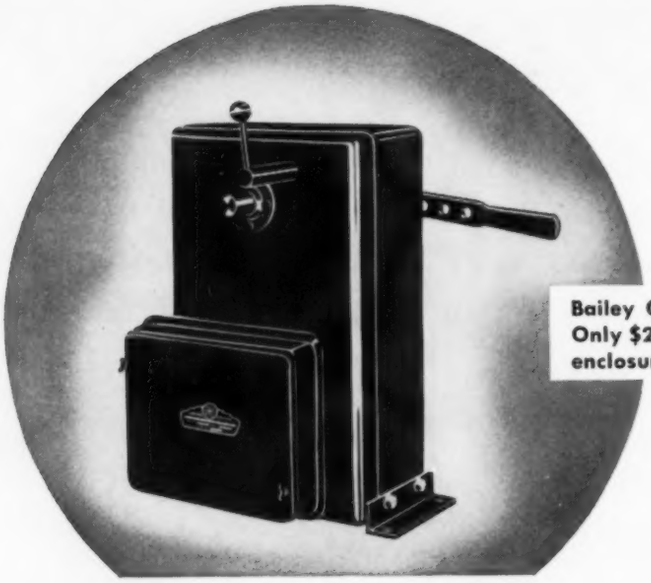
STEEL MILL MACHINERY

Designers and Builders of:

Steel Mill Machinery • Crushing Machinery • Rolls

Hydraulic Presses • Special Machinery • Steel Castings

MM-16-R



Bailey Control Drive, Type AC44P Model 200. Only $210.00 F.O.B. Cleveland, complete with enclosure, positioning relay and hand operator.

Want Better Flow Characteristics from Your Regulating Devices?

This new, small, piston-operated Bailey Control Drive will improve the flow characteristics of butterfly valves, dampers, hydraulic couplings, feeders and similar regulating devices. Adjustment is simple; any desired relation between drive motion and pneumatic signal may be secured.

You can install this compact pneumatic drive power unit in any position on a column, pipe, or flat surface—and connect it to the regulating device with standard Bailey linkage, available from stock.

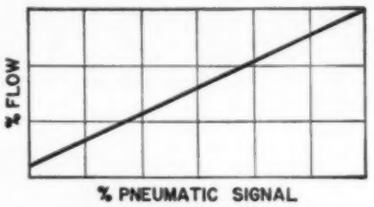
Speed (time required for full travel) is adjustable to suit your requirements. Bailey Control Drives operate on standard SAMA pneumatic signal ranges of 3 - 15 or 3 - 27 psig.

AVAILABLE FROM STOCK in 3 standard sizes

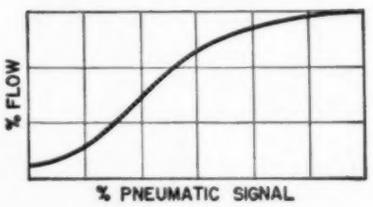
Type	Piston Dia. Inches	Piston Stroke Inches	Torque ft-lb	Max. Travel Degrees	Approx. Dimensions Inches
AC816	8	16	1500	90	13 x 27 x 51
AC68	6	8	400	90	13 x 19 x 34
AC44	4	4	75	75	10 x 11 x 19

P-28

The New Bailey Control Drive gives you THIS—



instead of THIS



BAILEY METER COMPANY

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CLEVELAND 10, OHIO

Complete Controls for Process Plants

BAILEY METERS

Controls for

TEMPERATURE
PRESSURE
GAS ANALYSIS
FLOW LEVEL
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FOR MORE INFORMATION
FILL OUT AND MAIL

☐ I am interested in Bailey Control Drives. Mail me Spec. CA04C

☐ I am interested in Bailey Control Linkage. Mail me Spec. CA942B.

Name_____

Title & Company_____

Street & Number_____

City & Zone_____ State_____

and was with the William Ganshow Co. before joining Kropp Forge Co. in 1922 as an agent in the sales department.

A. M. Riddle has been appointed executive assistant to the president of the Colorado Fuel and Iron Corp. In addition to his new responsibilities, emphasis on new business development will be continued through market and economic research. His time will be divided

A. M. RIDDLE

between the western and eastern divisions of the corporation. Mr. Riddle, who has more than thirty years' experience with CF&I, was first employed in the fuel division at the Segundo coke oven plant. He was later transferred to Pueblo, and in 1930 joined the president's staff in Denver.

W. E. Spaninger was appointed director of purchases and production manager of Lee Wilson Engineering Co., Inc. He also takes charge of assembly plant operations. It was also announced that **C. C. Blackman** becomes assistant chief engineer and **R. R. Hill** takes over as superintendent of the service department in charge of all field service and construction.

John D. Riley was appointed district manager of Cleveland, Ohio office of Link-Belt Co. Also appointed was **Harry G. Andersen** as district manager of the Newark, N. J., office. Mr. Riley joined Link-Belt in 1934 and for five years successively served in various departments of the company's Philadelphia, Pa., plant. In 1939 he was transferred to the Boston, Mass., office as district sales engineer and, later, became district manager at Newark. Mr. Andersen has been Link-Belt's district manager at Birmingham, Ala., for the past three years. He started with the company in 1937 at the Pershing Road plant in Chicago, where he served in various capacities in the engineering department and Chicago district sales office. In 1948 he was transferred to the Milwaukee office to serve as district sales engineer.

John G. Fleming has been appointed to the newly created position of product planning manager of the Bristol Co. According to the announcement this arrangement is intended to provide a more concentrated and directed approach to the company's short term and long range planning of new and improved instrumentation.

G. A. Fuchs was appointed general superintendent, Fire Brick Division, Laclede-Christy Co. He will be responsible for the operation of all of the company's fire brick and silica plants. Mr. Fuchs joined Laclede in 1948, and during this time handled labor relations and was manager of high alumina and silica sales until his recent promotion.

Carl F. Haertel was named divisional works manager of the foundry and weld shop of the Falk Corp., Milwaukee, Wisc. **Foster C. Koehn** has been appointed director of plant engineering. **B. C. Bugbee, Jr.**, former machine shop general superintendent, has been appointed divisional works manager of machine shops and general services. **Charles Fuerst** has been named general foundry superintendent.

Thomas H. Brumagin was named chief engineer of the Ajax Flexible Coupling Co., Inc.

E. Clair Book was named purchasing agent of Lukens Steel Co., succeeding **Hugh Kenworthy.** Mr. Kenworthy will remain in an advisory capacity until his retirement, June 30.

Francis Weiss has been appointed director of the newly created development department of the Alliance Machine Co. Mr. Weiss, who has been associated with the Steelton Plant of the Bethlehem Steel Corp. for

FRANCIS WEISS

14 years, will have a four-man staff charged with the development and improvement of present Alliance products.

L. W. Jordan has been appointed vice president, Pacific region of the Linde Air Products Co., with headquarters in San Francisco. Mr. Jordan joined Linde in 1925. He became San Francisco district manager in 1930. Two years later he became manager of the dis-

trict office in Los Angeles. In 1935 he was appointed manager of the Pacific Coast region.

Howard H. Chapin has been appointed superintendent of the 98-in. cold rolling mill, at the Cleveland, Ohio plant of Republic Steel Corp. Mr. Chapin, a

HOWARD H. CHAPIN

twenty-year veteran with the company, had been assistant superintendent of the mill. He will be succeeded in that post by **George R. Goss** who had been turn foreman on the 98-in. hot mill. The new superintendent joined Republic in 1934 at Warren, Ohio, and came to Cleveland in 1937 as finishing foreman at the strip mill.

GEORGE R. GOSS

He was promoted to turn foreman, rolling, in 1941, and advanced through the positions of general foreman, finishing, and general foreman, rolling, to assistant superintendent in 1951. Mr. Goss held various positions in hot strip rolling from 1934 through 1946 when he became turn foreman on the 98-in. mill in 1946.

Frank M. Mansfield III, has joined Carboloy Department of General Electric Co., Detroit, Mich., as manager of product programming. He was formerly Detroit district engineer for Torrington Co.

William Adam, Jr. was elected president of Ajax Electric Co., succeeding **Dr. G. H. Clamer. John E. Haig** and **Leon B. Rosseau** were elected vice presidents. Dr. Clamer will continue as president of Ajax Electro Metallurgical Corp., Ajax Electrothermic Corp., and Ajax Engineering Corp.

W. D. Sullivan has been elected a vice president of the Babcock & Wilcox Co. and placed in charge of the manufacturing department of the company's boiler division. Mr. Sullivan was formerly regional manager of the manufacturing department.

Robert G. Heers has been appointed to the new position of manager, mining and raw materials, for Kaiser Steel Corp. Mr. Heers has been with the company since 1943 and for the past nine years was manager of the Sunnyside Coal Mines, Sunnyside, Utah. His office will

ROBERT G. HEERS

be located at the Fontana, Calif. plant. In his new position he will plan mining operations and the flow of material from the coal mines in Utah and the company iron ore properties at Eagle Mountain, Calif., to the steel plant in Fontana. He will coordinate this flow with the raw materials department at the plant, central point in providing raw materials needed for operation of the blast furnaces and open hearths.

M. Nielsen, vice president of the Babcock & Wilcox Co., has been elected a member of the board of directors and placed in charge of the company's boiler division. Mr. Nielsen joined Babcock & Wilcox in 1924 and has had wide experience in the erection, contract and manufacturing departments of the company. In 1947 Mr. Nielsen became superintendent of production at the company's largest plant in Barberton, Ohio and was made an executive assistant in charge of the contract division in 1950. He was elected an assistant vice president in 1952 and vice president in charge of the boiler division's manufacturing department in 1953.

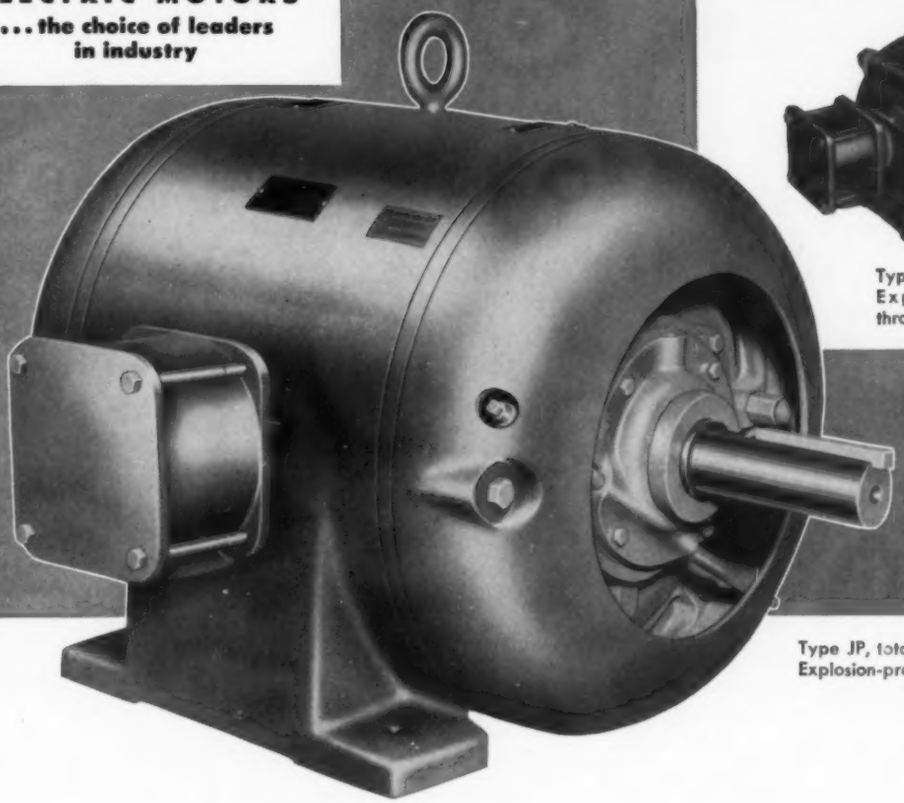
Ralph Morse was named plant engineer of Chandeysson Electric Co. In his new capacity, Mr. Morse will be in charge of all plant utilities, construction and maintenance. He will also supervise maintenance of all plant equipment and will carry out special assignments for the engineering and plant manager.

Wagner®

ELECTRIC MOTORS

... the choice of leaders in industry

Type JP, non-ventilated. Explosion-proof. ½ through 1½ hp.



Type JP, totally-enclosed fan-cooled. Explosion-proof. 2 to 250 hp.

for extra protection against corrosion

SPECIFY Wagner CAST IRON FRAME MOTORS

Here are stock motors specifically designed for use in chemical plants, oil fields, refineries, steel mills—for rugged industrial applications where dust, dirt, moisture, or corrosive vapors are present.

These motors are totally-enclosed in corrosion-resistant cast iron and all parts exposed to the atmosphere are of corrosion-resistant material —including the nameplate. They feature completely protected laminations . . . special varnish treated windings . . . and a running shaft seal.

Wagner Cast Iron Frame Motors are available in fan-cooled standard and explosion-proof types in ratings from 2 to 250 hp, and in non-ventilated standard and explosion-proof types in ratings from ½ through 1½ hp. Wagner Bulletin MU-132 gives complete information.

A skilled Wagner engineer can help you select a Wagner Motor to meet your most exacting specifications. Call the nearest of our 32 branch offices, or write us.

Wagner Electric Corporation EST. 1891

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ELECTRIC MOTORS
TRANSFORMERS
INDUSTRIAL BRAKES
AUTOMOTIVE BRAKE SYSTEMS— AIR AND HYDRAULIC

MH-1

hot days will come again—
be prepared with . . .

LINTERN AIRE-RECTIFIERS

It is fast becoming standard practice to provide normal working temperatures by means of air conditioning throughout industry at the worst spots — wherever the handling of hot metal increases already excessive temperatures.

Outstanding among the advantages resulting from the use of Lintern Aire-Rectifiers for cranes and pulpits are increased production due to men working under normal, healthful conditions; improved personnel relations; reduction of wild cat work stoppages; elimination of relief men and premium rates. These savings soon equal the capital investment for an Aire-Rectifier.

Cab is air conditioned with Lintern Aire-Rectifier.

Since we have a complete line of models to meet all requirements — and priced according to capacities — the total investment for Lintern Aire-Rectifiers is the lowest consistent with good performance. *Maintenance is a minor item.*

May we suggest that you anticipate your requirements and order now so as to be prepared for the hot weather that is sure to come, thereby benefiting by: (1) delivery in ample time to maintain a high level of production regardless of the heat and (2) installation before the rush season with its increased costs.

THE LINTERN CORPORATION
ROUTE 20, EAST • PAINESVILLE, OHIO

Dr. Raymond B. Seymour was appointed president of the Atlas Mineral Products Co. Dr. Seymour, the originator of furan cements, joined the firm as chief chemist in 1939. Since 1949, he has been executive vice president and a member of the board of directors.

Alvin L. Krieg has been appointed director of public relations for United States Steel Corp. in the Utah-Intermountain district, with headquarters at Salt Lake City, Utah. Mr. Krieg, who has been assistant director of public relations for U. S. Steel in the Cleveland, Ohio district since 1949, succeeds **Paul Sullivan,** who was appointed director of public relations in the corporation's Chicago, Ill. district.

Charles A. Grim has been appointed assistant product manager of the cold rolled division of Crucible Steel Co. His new duties include sales service and sales development work with the company's eastern branches.

William S. Doremus was appointed Ohio sales and service engineering representative of the Torrington Manufacturing Co., spring machine division. He will also perform sales engineering assignments throughout the firm's Pittsburgh, Detroit, Chicago and central Canadian distribution areas.

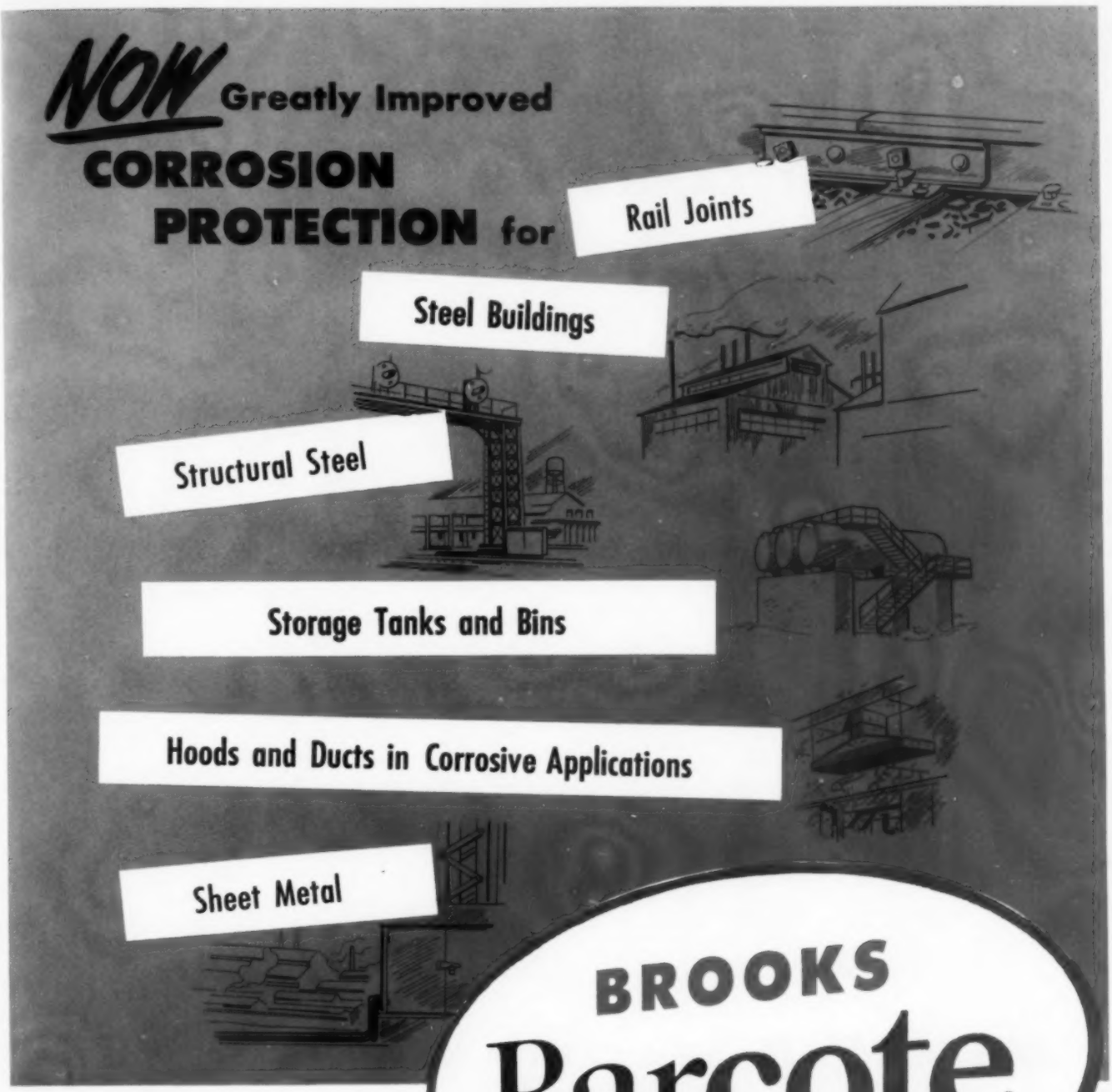
Obituaries

E. T. Wilson, Jr., sales representative of the Tubular Products Division of the Babcock & Wilcox Co., died February 24. Prior to joining Babcock & Wilcox, he was purchasing agent for the Cascade Manufacturing Co., an affiliate of Electric Steel Foundry and the Hyster Co. He represented B&W's tubular products division in the Oregon, Washington, British Columbia, Alberta and Saskatchewan area.

Frank E Moore, 76, chairman of the board, Mathews Conveyor Co. died, February 6. Mr. Moore joined the Mathews Gravity Carrier Co. in St. Paul, Minn., shortly after the company was founded in 1905 and brought the company, now Mathews Conveyor Co., to Ellwood City, Pa. in 1912, where he served as its president until 1948, when he became chairman of the board of directors, the position he held at his death.

Stirling Murray Rust, chairman of the board and a founder of the Rust Engineering Co., Pittsburgh, Pa., died January 29. He was 72 years of age. Mr. Rust came to Pittsburgh in 1898 as a laborer for C. G. Hussey & Co. He next worked as a blue-print boy with Jones & Laughlin Steel Co., and later with other steel companies in design, construction and operation of steel plants in Pittsburgh and other cities. In 1905 he joined with two brothers to form the Rust Engineering Co. in Birmingham, Ala. In 1913 a branch of the company was established in Pittsburgh. In 1920 the firm was incorporated with headquarters in Pittsburgh, Mr. Rust becoming president. He served in that capacity until 1944, when he became chairman of the board.

George W. Shaffer, plant and field superintendent of S. P. Kinney Engineers, Inc., died recently.



BROOKS

Barcote

Brooks Barcote, which sets to a semi-hard coating of pure lubricant, provides exceptional corrosion protection in all the applications indicated. This new leaded-petroleum compound produces a film which expands and contracts without flaking, cracking, pulling away or blistering. Barcote resists the action of salt water, is soluble in petroleum solvents and never clogs spray equipment.

Write for Brooks Pamphlet 61.

- **Low cost, with long service**
- **Flows at 0° F**
- **Has penetrating action sufficient to carry it behind scale and through rust**

THE BROOKS OIL CO.

Since 1876

Executive Offices and Plant, Cleveland, Ohio
Executive Sales Offices, Pittsburgh, Pa.
Canadian Offices and Plant, Hamilton, Ontario
Cuban Office, Santiago de Cuba

Warehouses in Principal Industrial Cities

the first helper's first helper at **INLAND STEEL**

ASKANIA OPEN HEARTH CONTROLS

In the new open hearth shop at Inland Steel Company's Indiana Harbor works, this panel houses one of four complete Askania control systems.

No control replaces the skill and judgment of an experienced open hearth operator. But an Askania installation adds to his skill by putting accurate and dependable control at the tips of his fingers. It is truly the first helper's first helper.

This is modern open hearth control—completely automatic but flexible. In the hands of your operators, it is a tool that helps them make more steel and better steel for less money. Furnace pressure is controlled to a hairsbreadth. Air flow and fuel flow are precisely proportioned to each other. Flow of atomizing steam to the burners is closely regulated to the operator's setting. Automatic reversal cuts fuel-off time to a few seconds, uses checker heat most effectively. A complete record of all that happens lets the operator duplicate his results in heat after heat.

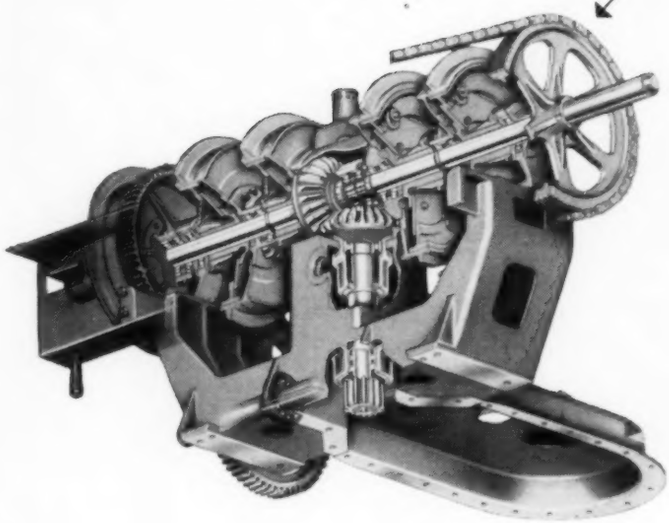
Steel men rely on Askania Controls—common-sense controls that make their job easier and the results better. Askania equipment is simple and sturdy—designed and built to do the hardest jobs for the longest time.

Write for Bulletin 115, Askania Open Hearth Furnace Control.

ASKANIA REGULATOR COMPANY
246 E. Ontario Street, Chicago 11, Illinois
Subsidary of General Precision Equipment Corp.

For positive bearing protection

THEW-LORAIN *specifies* KLOZURE* Oil Seals



At the left is a cut-away illustration showing the "heart" of Thew-Lorain's "TL" Series of power cranes and shovels—the clutch shaft bevel gears which operate the turntable of Lorain TL-25's. Dependable KLOZURES protect 5 of the clutch shaft bearings under the most rugged service conditions where operating temperatures often exceed 250° F.

MODEL 53 KLOZURE

MODEL 51 KLOZURE

Cross-sectional views of finger-spring KLOZURES; hycar sealing element for normal services—silicone rubber sealing element for elevated temperatures.

Thew-Lorain power shovels and cranes must withstand rugged operating conditions—where dust, dirt, and moisture are the rule rather than the exception. That's why TL engineers specify dependable KLOZURE Oil Seals for the inner clutch assembly (illustrated) and many other bearing applications. These superior oil seals give maximum bearing protection by keeping the lubricant *in*, dirt and moisture *out*.

Prolong the life of your bearings! Standardize on Garlock KLOZURES and prevent breakdowns and resulting losses in production.

KLOZURE Oil Seals are made in a complete range of sizes and in many models. For full information call your Garlock representative or write for KLOZURE Catalog No. 10.

THE GARLOCK PACKING COMPANY, PALMYRA, NEW YORK

Sales Offices and Warehouses: Baltimore • Birmingham • Boston • Buffalo • Chicago • Cincinnati • Cleveland • Denver Detroit • Houston • Los Angeles • New Orleans • New York City • Palmyra (N. Y.) • Philadelphia • Pittsburgh • Portland (Ore.) • Salt Lake City • San Francisco • St. Louis • Seattle • Spokane • Tulsa.

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PACKINGS, GASKETS, OIL SEALS, MECHANICAL SEALS, RUBBER EXPANSION JOINTS

any way you look at it . . .

portable grinding is profitable grinding with SIMONDS resinoid bonded grinding wheels

Spot grinding! Smoothing welds! Grinding in corners! Working with odd shapes! Wherever low-cost, top-operating efficiency is essential, Simonds portable wheels fill the bill. They cut fast, hold their shapes, give long service, and include everything you need—straight wheels, cup wheels, cones, pot-balls and blind-end wheels. Resinoid bonded for high speeds up to 9500 s.f.p.m. Write for free folder ESA-62.

Rotor type cup wheel—cross section shows steel bushing flange and safety ring.

SIMONDS ABRASIVE CO.
PHILADELPHIA 37, PA.

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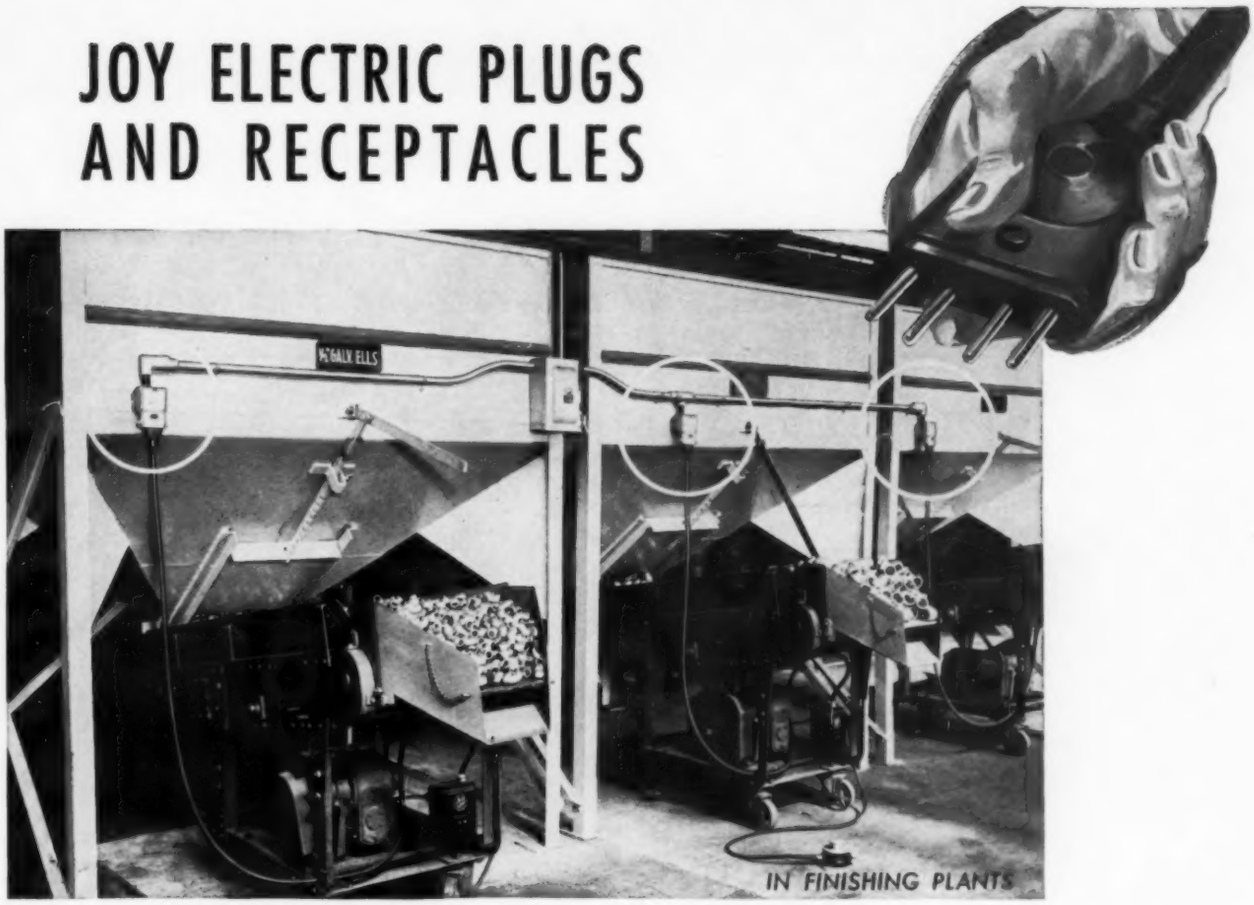
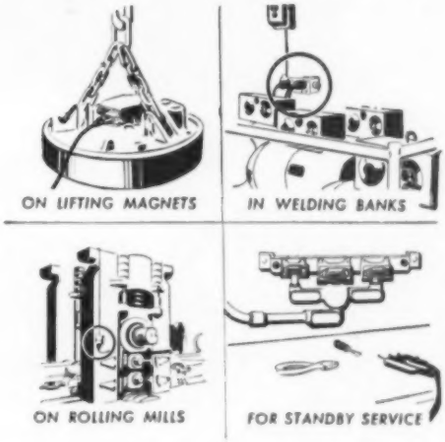
JOY ELECTRIC PLUGS AND RECEPTACLES



IN METAL PROCESSING PLANTS . . . STEEL MILLS ROLLING MILLS & FOUNDRIES

To earn the OK of Heavy Industry, electrical plugs and receptacles must function perfectly for long periods under conditions that quickly destroy many types now available for general industrial needs. That's our reason for believing the growing use of JOY connectors in metal processing plants, steel mills, rolling mills and foundries should be of particular interest to you. We're sure you'll want to know more about their inherent advantages (*see next paragraph*) before placing your next electrical connector order.

Factory molded to cable as one-piece Neoprene units, JOY connectors are little affected by rough handling, hard blows, grime, oil, moisture or vibration. Once installed, little or no maintenance is required. Available in designs and capacities to meet almost any portable power connecting requirement. Why risk electrical connector misfits when today's best actually costs less, in the long run. Full details including free literature available without obligation. Ask for them, today!



Consult a Joy Engineer

- ☆ *FACTORY MOLDED AS ONE-PIECE NEOPRENE UNITS*
- ☆ *SHATTER-PROOF, MOISTURE-TIGHT, WEAR-RESISTANT*
- ☆ *HIGHLY RESISTANT TO SUNLIGHT — OIL AND ACID*
- ☆ *EASILY INSTALLED — PROVIDE YEARS OF SERVICE*

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M. E. 1151.1

JOY MANUFACTURING COMPANY

HENRY W. OLIVER BUILDING, PITTSBURGH 22, PENNSYLVANIA

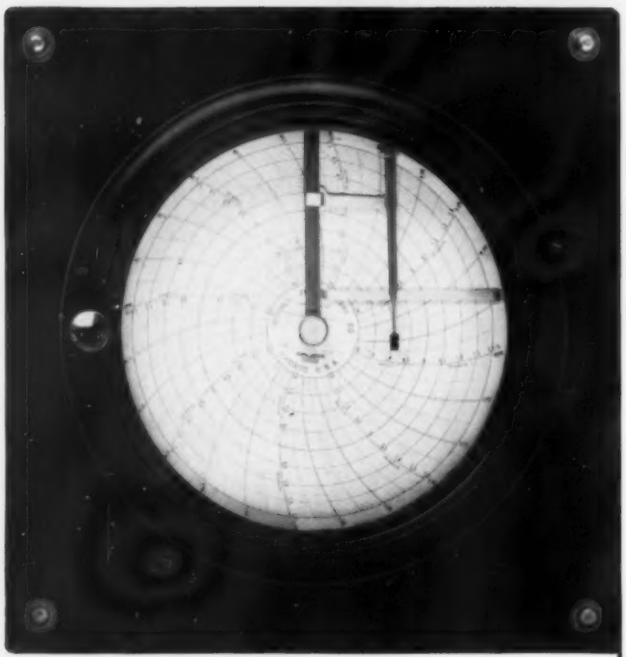
IN CANADA: JOY MANUFACTURING COMPANY (CANADA) LTD., GALT, ONTARIO

accurate— sensitive— trouble-free— easy to service—

Four reasons for choosing these Republic Low Pressure Instruments to measure flow or pressure of gas and air

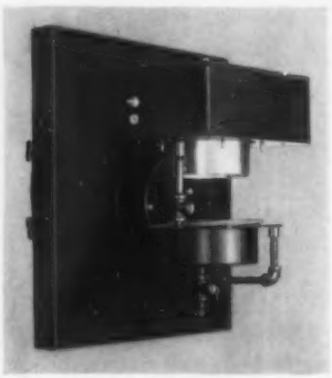
in

OPEN HEARTH FURNACES
SOAKING PITS
REHEATING FURNACES
COKE OVENS
SMELTING FURNACES

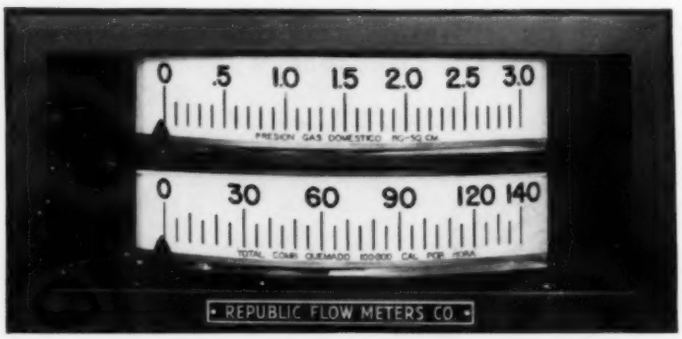


Republic Oil Sealed Bell Recorder at left responds to the slightest changes in furnace pressure and stack draft, and works independently of other controls. Operating principle is so simple that a minimum of maintenance is required. Sealed bell withstands high temperatures and will not crack, rupture or wear out. For pressure or vacuum measurement, the Recorder may be connected directly to a furnace or pipe line. For differentials, it may be connected across an orifice.

Recorder has ranges 0-0.2″ H_2O and 0-8″ H_2O at static pressures to 10 psi. On low range, large 4″ diameter bell gives sensitivity of ±.001″ H_2O.



For quick periodic inspection and cleaning, mineral oil reservoir at rear of Recorder may be lowered by disconnecting one pressure connection and four bolts. Calibration is not changed.



Horizontal Indicator is operated by a tough, resistant diaphragm made of polythylene plastic. Each Indicator is separate and may be individually removed or adjusted. Indicator arm swings on jeweled bearings for friction-free accuracy. Internally illuminated scales may show pressure, draft, pressure-draft combination or differential pressure. Ranges from 0-0.2″ H_2O to 0-40″ H_2O.

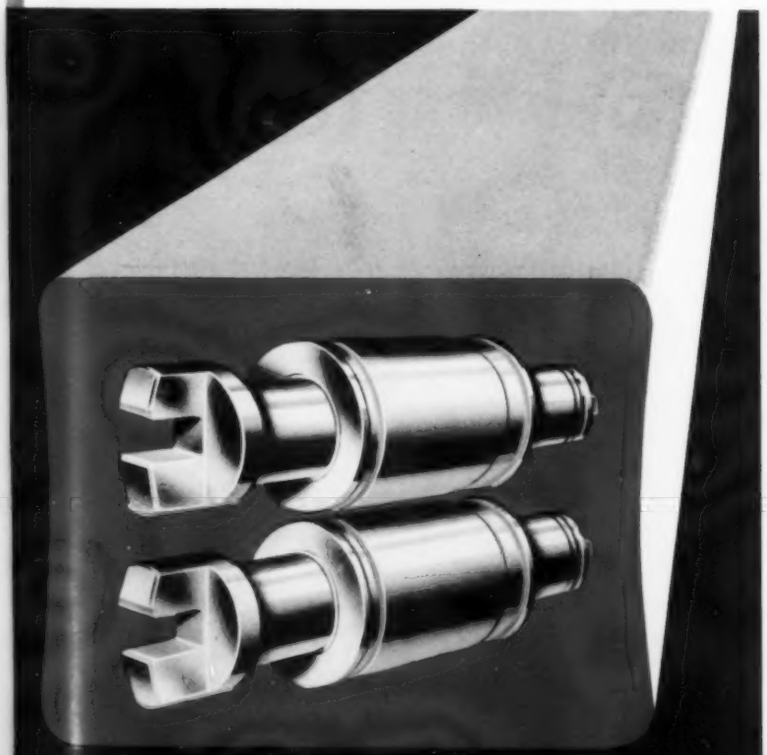
Two Indicators are often mounted together to read air flow—gas flow ratio in furnace firing. They may be calibrated so their pointers line up when air and gas are in the correct ratio.

Both instruments fully described in Bulletin 802. Write for your copy today.

REPUBLIC FLOW METERS CO.
2240 Diversey Parkway, Chicago 47, Illinois

IN SLABBING MILLS AND BLOOMING MILLS

Productioneering begins with Mack-Hemp Rolls



If you've been keeping your eye on what's new at Mack-Hemp, you already know about the improvements in Striped Red Wabbler blooming and slabbing mill rolls.

But, just in case you missed hearing users talk about these *production tools*, you'll be interested in their capabilities.

Actually, Mack-Hemp has applied some new heat-treating techniques to reduce susceptibility to fire-cracking. These metallurgical improvements are important because they help increase blooming and slabbing mill production.

There's no time like the present to discuss these efficient Striped Red Wabbler Rolls, and you'll certainly want to know something about their service records. Meanwhile, though, you'll find it's worthwhile to keep an eye on *everything that's new at Mack-Hemp.*

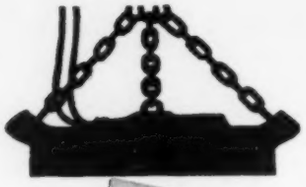
MACKINTOSH-HEMPHILL COMPANY PITTSBURGH U.S.A.

MACKINTOSH-HEMPHILL CO.

Makers of the Rolls with the Striped Red Wabblers

PITTSBURGH AND MIDLAND, PA.

MACKINTOSH-HEMPHILL PRODUCTS INCLUDE: all types of cast mill rolls . . . improved Johnston patented corrugated cinder pots and slag handling equipment . . . Mackintosh-Hemphill rotary straighteners—electronically controlled contouring lathes—screw feed roll turning lathes—heavy duty engine lathes . . . shears . . . end-thrust bearings . . . steel and special alloy castings . . . reversing hot strip mills . . . Y-type cold strip mills



You can't beat **Ohio Magnets** for

heavier construction

OHIO BOLTED MAGNETS. 12 to 65" dia. 6-coil types in 39 to 65"; 8-coil in 55 & 65". Strap coils over 39". Bolts protected in recessed wells. Also capsule-coil over 45".

OHIO WELDED MAGNETS. 39 to 65" dia. Lightweight models in 39 & 45". 6-coil in 46, 55, 65"; 8-coil in 55 & 65". Weld on top where it can't get dented in. Also capsule-coil over 45".

OHIO BASKET MAGNETS. 55 & 65" 4-coil, & 65" 6-coil. For extra heavy-duty service. No weight carried by bolts. Also capsule-coil over 45".

In slag reclamation or rough service—or any use where magnets are subjected to hard knocks—you need the extra heavy construction and greater lifting power of Ohio Magnets.

This super-strong Ohio Basket Magnet has an outer ring with integrally cast fenders that project beyond magnet diameter to ward off and protect against damaging blows. Extra heavy top plate is held in place with strong nickel-steel bolts.

For extra magnet life, extra magnet value—specify Ohio Magnets. Remember, Ohio Magnets lift larger loads longer—*especially with Ohio Magnet Controllers.*

Send for Bulletin No. 112. Offices in principal cities listed in Classified Directory.

Ohio gives prompt service in reconditioning and rebuilding magnets

A-7309

THE OHIO ELECTRIC MFG. CO.
5400 DUNHAM RD., • CLEVELAND, OHIO

ohio ELECTRIC

CHESTER BLAND
President

Publication Service...

MARCH, 1954

You Can Obtain...

... any of the bulletins reviewed in the Publication Service of the IRON AND STEEL ENGINEER without obligation or cost. Simply circle the desired item numbers on one of the prepaid postal cards and mail. The requests will be forwarded to the manufacturers involved who will send the bulletins to you.

(1) Stainless Steel Selector

A new slide rule-like chart which quickly answers the question of exactly what type of stainless steel should be used for about 95 per cent of operations requiring its use has been published by Crucible Steel Co. of America. The chart grew out of findings that most stainless metal-working failures and losses result from wrong selection of stainless steels. The use of the chart approaches the problem in much the same way as the metallurgical engineer in selecting the proper stainless steels for an application. The front contains a comparison of stainless physical and mechanical properties, and elevated temperature properties. The reverse side gives a large number of the important characteristics of stainless.

(2) Rolling Mills

A revised and expanded brochure of rolling mills and accessory equipment, is available from E. W. Bliss Co. The new 60-page booklet contains a variety of installation photographs and descriptive data on mill equipment for the steel, brass and aluminum industries. Also included is a 16-page section containing engineering tables and charts of value to engineers in the metal-producing industries.

(3) Stock Furnace and Oven Controllers

Furnace and oven control instruments are listed in a booklet published by the Bristol Co. These stock instruments include indicating pyrometers and controllers for permanent mounting or portable use, indicating thermometer controllers, traveling oven recording thermometer and pyrotrol combustion safeguards. Other control accessories, such as thermocouples and protection tubes, and Bristol's potentiometric test set, are also shown. (Bulletin P1262).

(4) Pneumatic Transmitter

Recently issued by Hagan Corp. is a bulletin which illustrates and describes a low-head type differential-pressure pneumatic transmitter. Designed particularly for measuring liquid fuels, and the automatic control of the fuel-air ratio, the device produces a pneumatic output signal proportional to the differential pressure across a built-in orifice. Other features covered in the four-page booklet include: construction details and cut-away view showing the specially designed no-sealing-fluid measuring assembly, economy of air consumption — averages 0.2 cfm, operating characteristics, and simplicity of calibration. (Bulletin 2753).

(5) Muffle Furnace

Vertical type muffle furnaces are described in a new bulletin just released by Surface Combustion Corp. It includes a detail construction drawing, depicting important design features, photographs of typical applications with types of parts being heat treated, and descriptions of accompanying equipment — controlled cooling pits and prepared atmosphere generators. Handy engineering data and charts on the application of RX atmospheres to heat treat processing are also included. (SC-165).

(6) Emergency Lighting Equipment

Published recently by Exide Industrial Division of the Electric Storage Battery Co. is a pamphlet on a new line of auxiliary emergency lighting equipment approved by Underwriters Laboratory. The booklet is designed to assist architects, builders, contractors, executives, engineers, purchasing agents and others needing such information, in selection of emergency lighting equipment. Schematics, layouts and illustrations of typical emergency lighting installations are supplemented by suggested specifications conforming with sections of the recently revised National Electrical Code dealing with 6-volt emergency lighting equipment. The recently introduced Exide models M and T are featured. Illumination curves are included for the 6-volt battery supplied with these units, which utilize a storage battery specifically designed for emergency lighting use. Recommended installation procedures for emergency lighting equipment show how to get the most out of the equipment at minimum cost. (Form 4808).

(7) Creep Testing Machines

Five types of creep testing machines for standard sized metal specimens are presented by Baldwin-Lima-Hamilton Corp., in new 12-page bulletin. The lever arm and screw type creep machines, Microformer type and new SR-4 type automatic relaxation machines, and a constant strain rate machine are included in the bulletin with pictures, dimensional diagrams, and specifications. (Bulletin 4208)

(8) Pump and Reservoir Assemblies

A four-page illustrated catalog has been published by Trabon Engineering Corp. dealing with their line of Hydra-Lube pumps and reservoir assemblies. The pumps are designed for automatic lubrication of hydraulically powered equipment, such as machine tools, presses and mining machines. They connect to the supply line of any double acting cylinder. No control valves are required because twin-sealing with vent between prevents the mixing of lubricant and hydraulic fluid. Three, five and twelve pound reservoir assemblies for grease or oil are available for use with the pump. Dimensions of both the pump and reservoir assemblies are included in the catalog, as well as a diagram drawing of the method of connecting the pump to any hydraulic circuit. (Catalog A-1-54).

(9) Electrical Control System

Colorfully illustrated, a 24-page booklet issued by the Clark Controller Co., describes the many advantages of centralized electrical control systems through use of their motor control centers. Typical installations, specifications, construction details and helpful planning tips are also featured. Invaluable reading for plant, project or planning engineers and plant layout departments.

(10) Electric Heat Treat Furnaces

A new bulletin covering electric heat treat furnaces has just been published by Holcroft and Co. The booklet describes four types of electric heating elements and their methods of mounting. It also classifies heat treat furnaces according to their methods of handling stock.

(11) Foundry Mechanization

The application of equipment for mechanization of ferrous and nonferrous foundries and its use in increasing production and producing better castings are covered in a new 40-page book published by Link-Belt Co. This comprehensive book will be helpful in selecting a specific piece of materials handling equipment to improve a particular phase of production or as an aid in planning a completely mechanized foundry operation. Descriptions of sand preparation and mold, core, casting and sand handling equipment are supplemented by over 70 pictures of actual installations. Seven tested foundry layouts, each pertaining to a different type and capacity operation, are given in two-color drawings. Sand preparation equipment described includes Roto-Louvre dryers and coolers for core sand; mullers and paddle mixers to knead and mix sand and bonding materials; revivifiers to thoroughly disintegrate, blend and cool sand so that it will ram to a more uniform density in the molds; screens for the removal of foreign matter from sand; and belt, oscillating, and apron conveyors to handle sand from and to work areas; table and belt feeders for withdrawal of sand from storage hoppers; and bucket elevators to elevate sand. Overhead trolley conveyors are described as an effective core handling medium. This type of conveyor is particularly adaptable because of its almost unlimited handling capacity and flexibility of path. Mold handling equipment described includes car-type conveyors, track mounted and propelled by means of steel chain; pallet conveyors available in three types (roller, sliding and dumping); and trolley and roller conveyors. Heavy-duty foundry shakeout installations are pictured. This unit has proved itself to be an efficient separator of sand from castings. Apron, trolley and oscillating conveyors for handling castings are also described. (Book 2423).

(12) Heat Exchanger and Condenser Tubing

A new folder, of particular interest to individuals involved in the design, manufacture and application of heat exchangers and condensers, has been issued by the Tubular Products Division of The Babcock & Wilcox Co. The folder lists the analyses and mechanical properties of 29 carbon, alloy and stainless tubing steels used in various types of heat exchangers and condensers. Additional data presented in other tables include reference specifications and applications information. (Bulletin TB-329A).

(13) High Impedance Input Instrument

Description of a high impedance input instrument which can be used with source impedances varying from 0 to 50,000 ohms, without serious impairment of sensitivity, speed of response or damping is contained in a data sheet published by Minneapolis-Honeywell Regulator Co. No d-c pre-amplifier is required. Instruments are available for spans of two millivolts or greater, or 10 millivolts or greater. (Data Sheet 10.0-14).

(14) Lubrication Program

A booklet recently made available by the Pure Oil Co. approaches the problem of controlling lubrication application costs on the basis of reducing the number of lubricants used. In addition, the brochure suggests putting plant lubrication on a program basis to help prevent many maintenance troubles. The suggested program lists plant survey, lubrication schedule for each machine, lubrication inventory, perpetual inventory, concentrated responsibility and accurate lubrication records.

(15) Hydraulic Adjustable Dock Ramp

A new bulletin describing its 20,000-lb-capacity non-floating hydraulic adjustable ramp, is now available from Rowe Methods, Inc. This model, specifically engineered to make fast bridge connection between a loading platform and the bed of a highway truck, is raised or lowered to suit the requirements of each job by means of instant-acting push button controls. Subsequent adjustments may be made with the rated load on the deck, using the ramp's heavy-duty hydraulic power system. When not in use, the ramp is positioned flush with the platform floor to permit normal cross traffic.

(16) Drop Forging

Available from the Billings & Spencer Co. is a new, informative booklet on drop forging. Printed in two colors, the new literature contains a brief history of the company, a short description of how drop forgings are made and useful information on facilities for producing drop forgings. The booklet has been prepared to familiarize users of commercial drop forgings with the company, one of the oldest in the nation.

(17) Mechanical Flow Meter

Full description of their mechanical flow meter is offered by Penn Industrial Instrument Corp., in a new catalog. This meter, introduced over 35 years ago, has been redesigned to better conform to present-day panel instrumentation. The basic operating principle has not been changed dynamically or dimensionally, so that it is still considered the most powerful meter available. New design incorporates a rugged simplicity and is virtually trouble-free, requiring little or no maintenance over long periods of time. The catalog offers all pertinent data including description of operating principle, easy method of calibration and convenient range change feature. Close-up photographs are used to illustrate inside and outside view of meter. Complete information is given on capacities, pressures and materials of construction. Separate section includes drawing with dimensions and suggested installation method. (Catalog 1027).

(18) Calculating Horsepower Capacity

A six-page interim bulletin which provides in condensed form the necessary information on the new method of calculating the horsepower capacity of a "Texrope"

v-belt drive has been released by Allis-Chalmers Manufacturing Co. The belt ratings resulting from this new method take into consideration effect of belt length, ratio of the diameters of both the driving and driven sheaves upon the horsepower rating of the belt, and resultant belt life. These are features which were not adequately reflected in the former v-belt horsepower ratings. The new formula provides means of determining the ratings for both standard construction and high capacity v-belts. All sheave and v-belt manufacturers in the industry have approved and accepted the belt horsepower ratings derived from this new formula. (Bulletin 20B6956B).

(19) Low-Temperature Processing

Recently published by Air Products, Inc. is a 36-page booklet dealing with low-temperature processing. Included are sections on oxygen-nitrogen-aragon generators, cylinder gas, welding and cutting equipment, and apparatus used in low-temperature processes. Schematic drawings and a wealth of illustrations aid the presentation.

(20) Cutting and Grinding

The new four-page brochure produced by Master Chemical Corp. contains a pocket size 44-page booklet on cutting and grinding procedures. Both the brochure and the booklet contain charts and graphs showing recommended concentrations for machining different metals in all metal-working operations, as well as comprehensive technical data pertaining to proper methods to increase production and prolong tool life.

(21) Paint Selection

A recently published paint selection check chart of Wilbur & Williams Co., is a quick-answer guide to maintenance painting problems. It enables paint contractors, building contractors, maintenance superintendents, architects —any paint user—to immediately determine which paint products have all the important performance requirements for each paint. With this chart, it is possible to check and compare, point by point, all available paints, then to choose the ones that best meet requirements.

(22) Heat Transfer Applications

A 12-company report on the use of "Platecoils" in a variety of process heating and cooling applications has just been published in a 20-page brochure by Tranter Manufacturing, Inc. This bulletin shows how savings can be made in 12 different processing operations through factual reports on the experiences of companies who are making these savings. Reports run the gamut of heat transfer applications from alkaline stripping and flexseal coating to tar transfer and quench oil cooling. (Brochure No. 154).

(23) Fork Truck

The model F-39T10 electric powered, 10,000 lb capacity fork truck is illustrated and described in a new folder just released by the Elwell-Parker Electric Co. This truck has been designed to provide a heavy-duty machine capable of providing dependable and economical operation under even the severest operating conditions. In spite of its large load carrying capacity the truck's overall dimensions and weight have been held within practical limits. In designing the truck, particular care was given to factors of accessibility for maintenance and repair. The new literature is profusely illustrated and contains more than a dozen photographs showing the truck in a wide variety of applications, plus model shots and detailed views of components. Engineering drawings are also included. The folder lists complete design specifications, operating and construction features and applications. A full page is devoted to a detailed analysis of major components.

(24) Geared Turbine Generator

Geared turbine generators, 200 kw to 1500 kw, for both ac and dc service are the subject of a bulletin now offered by Worthington Corp. The bulletin describes engineering and construction features of the turbine generators, including two types of governing arrangements, hand and automatic nozzle controls, and other controls and accessories.

The geared turbine unit offers the following advantages over direct connected machines for driving generators up to and including 1500-kw capacity; low initial cost; peak efficiency regardless of generator speed; low speed exciter minimizes brush and commutator wear; either open or enclosed type generators may be selected depending on local conditions; relatively simple generator construction; unit can easily be arranged to operate over varying frequency ranges (50-60 cycle, 120-180 cycle, etc.). (Bulletin 1969).

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IRON & STEEL ENGINEER
1011 EMPIRE BUILDING
PITTSBURGH 22, PA.

IRON & STEEL ENGINEER
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PUBLICATIONS CURRENTLY OFFERED by Iron and Steel Engineer Advertisers

ITEM	COMPANY	BULLETIN	DESCRIPTION
50	AMERICAN CHEMICAL PAINT CO.		Descriptive folder on Rodine.
51	AMERICAN WHEELABRATOR & EQUIPMENT CORP.	BULLETINS 894 AND 914	Description of descaling of steel strip and sheets.
52	ASKANIA REGULATOR CO.	BULLETIN 115	Information on open hearth furnace control.
53	BAILEY METER CO.	CA942B	Facts on control linkage.
54	BAILEY METER CO.	SPEC. CA040	Information on control drives.
55	BEDFORD FOUNDRY & MACHINE CO., INC.		Catalog gives details on Bedford cranes.
56	E. W. BLISS CO.	BULLETIN 40-A	Revised rolling mill brochure.
57	BROOKS OIL CO.	PAMPHLET 61	Information on improved corrosion protection.
58	BUSSMANN MANUFACTURING CO.		Complete facts about dual-element fuses.
59	CLARK CONTROLLER CO.		Descriptive literature on Clark type CY starters.
60	CRANE CO.	FOLDER AD1944	Facts on brass valves.
61	ELECTRIC CONTROLLER & MANUFACTURING CO.	BULLETIN 900	Details and specifications on all-welded magnets.
62	ELECTRIC CONTROLLER & MANUFACTURING CO.	BOOKLET 921	Information on three-direction control for cranes.
63	ELECTRIC CONTROLLER & MANUFACTURING CO.	BULLETIN 942B	Illustrated bulletin on tab-weld plate resistors.
64	ELECTRIC FURNACE CO.		Information on equipment and research facilities.
65	ELECTRIC MACHINERY MANUFACTURING CO.	BULLETIN 1107	Details on magnetic drives.
66	FARMERS ENGINEERING & MANUFACTURING CO.		Electronic communication and control data kit.
67	FARVAL CORP.	BULLETIN 26	Information on centralized lubrication.
68	FOOTE BROS. GEAR AND MACHINE CORP.		Information on drives and gearmotors.
69	GARLOCK PACKING CO.	CATALOG 10	Full information on oil seals.
70	GENERAL ELECTRIC CO.	GEA-6091	Unit-cooled motor bulletin.
71	GENERAL MOTORS CORP., HYATT BEARINGS DIVISION	CATALOG 150	General catalog on roller bearings.
72	C. B. HUNT & SON, INC.		Descriptive data sheets on control valves.
73	IDEAL INDUSTRIES, INC.		Handbook on commutator and slip ring maintenance.
74	INDUSTRIAL GEAR MANUFACTURING CO.	BULLETIN 152-A	Illustrated bulletin showing gear manufacturing plant.
75	KOPPERS CO., INC., FAST'S COUPLING DEPT.		Detailed descriptions, engineering drawings, etc. on couplings.
76	LINK-BELT CO.	BOOK 2416	48-page booklet on belt conveyor idlers.
77	LOVEJOY FLEXIBLE COUPLING CO.		Illustrated catalog on flexible couplings.
78	McDANEL REFRACTORY PORCELAIN CO.		New catalog on industrial porcelains.
79	MICHIGAN TOOL CO., CONE-DRIVE GEARS DIV.	BULLETIN 8901-50	Facts about cone-drive speed reducers.
80	MINNEAPOLIS-HONEYWELL REGULATOR CO., INDUSTRIAL DIVISION	CATALOG 9301	Reference data on radiamatic pyrometers.
81	NAGLE PUMPS, INC.	BULLETIN SWO	Facts on pumps for abrasive and corrosive applications.
82	OHIO ELECTRIC MANUFACTURING CO.	BULLETIN 112	Data on magnets and magnet controllers.
83	OKONITE CO.	BULLETIN IS-1053	Full information on Okonite insulated cables.
84	PITTSBURGH LECTROMELT FURNACE CORP.	CATALOG 9	Description of Lectromelt furnaces.
85	PLASTEEL PRODUCTS CORP.		Details on and sample of Plasteel roof deck.
86	POST-GLOVER ELECTRIC CO.	BULLETIN 500	Information on nonbreakable resistors.
87	RADIO CORPORATION OF AMERICA		Booklet describing industrial TV accessory and control equipment.
88	REPUBLIC FLOW METERS CO.	BULLETIN 802	Full description of pressure measuring instruments.
89	RUST-OLEUM CORP.		Complete literature and color chart on Rust-Oleum.
90	SIMONDS ABRASIVE CO.	FOLDER ESA-62	Facts about portable grinding wheels.
91	SKF INDUSTRIES, INC.	BULLETIN 365-S	Complete facts and engineering data on spherical roller bearings.
92	SUTTON ENGINEERING CO.	BULLETIN 25	Information on five roll straighteners.
93	S. G. TAYLOR CHAIN CO.	BOOKLET 12C	Facts and specifications on alloy steel chain.
94	UNITED STATES GRAPHITE CO.		Catalog on carbon brushes for electrical machines.
95	U. S. STEEL CORP., AMERICAN BRIDGE DIV.		Up-to-date information on electric melting furnaces.
96	WAGNER ELECTRIC CORP.	BULLETIN MU-132	Complete information on cast iron frame motors.
97	JOHN WALDRON CORP.	BULLETIN 551	Facts and data on couplings.
98	WALKER PROCESS EQUIPMENT, INC.	BULLETIN 10169	Facts on new blast furnace flue dust recovery plant.
99	WELLMAN ENGINEERING CO., ANKER-HOLTH DIVISION		Bulletin on complete line of Anker-Holth products.

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For Special Operations in Steel Mills...

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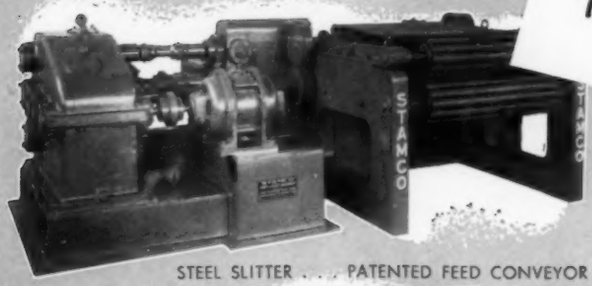

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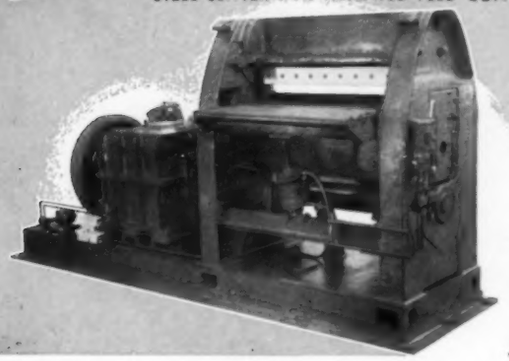

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REWIND REEL

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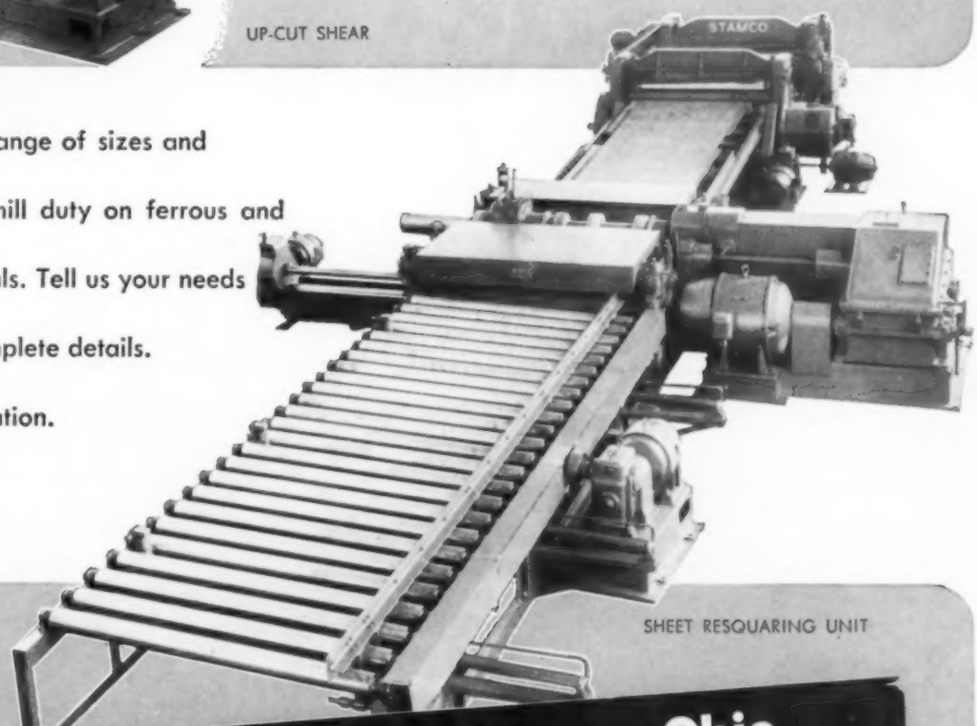
Stamco

for the equipment you need

Available in a wide range of sizes and speeds for warehouse and mill duty on ferrous and non-ferrous materials. Tell us your needs and we'll give you complete details.

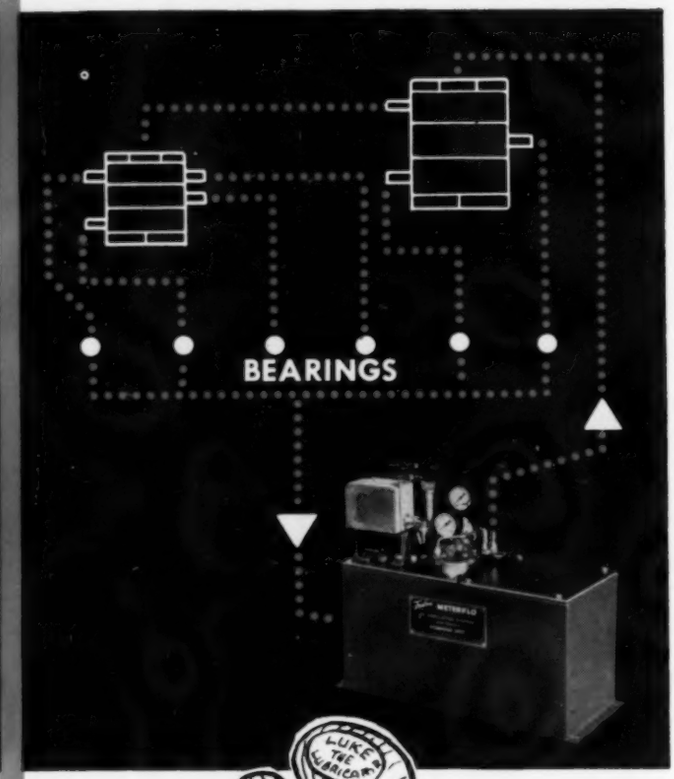
No obligation.



SHEET RESQUARING UNIT

• LAY YOUR SHEARING PROBLEMS AT STAMCO'S DOOR •

STAMCO, Inc., New Bremen, Ohio



Trabon's METERFLO OIL CIRCULATING SYSTEM *ELIMINATES TROUBLE*

ON 20-TON WELDING PRESS

This is one of an installation of 36 four-point welding presses in a large automotive plant, all automatically lubricated by TRABON METERFLO systems.

TRABON *positive* lubrication assures all of the 68 bearing points on each press the right amount of filtered oil at the right time. Remote indicating gauges are mounted in the left-hand corner column of the presses for easy visibility. Warning lights flash on in the event of interrupted flow of oil to the bearings.

This installation is typical of the thousands of TRABON automatic lubrication systems in operation in industry everywhere . . . under all manner of operating conditions, indoors or outdoors, underground or on the surface.

Trabon ENGINEERING CORPORATION
1814 E. 40th STREET • CLEVELAND 3, OHIO
Oil and Grease Systems

Equipment News...

DRY-CHARGE BATTERY

▲ Gould-National Batteries, Inc., is preparing to manufacture a new type of dry-charge electric storage battery, the first of its kind to be sold in the United States.

The feature of the new type of dry-charge battery is its ability to retain its initial charge over much longer periods of time than ever before possible, particularly under adverse temperature and moisture conditions. This quality may eliminate in large part the need for charging equipment which must now be on hand in so many of our world-wide military installations.

The savings in charging equipment is only one aspect of the comparative advantage held by the new dry-charge battery over the type now available. When needed for use, both types require the introduction of sulphuric acid, but the soaking period for the dry-charge is a fraction of that required by the present battery to make it ready to deliver current.

The new process will also make available to industrial storage battery users a new dry-charge type which can be kept indefinitely for stand-by without suffering deterioration. In the present dry-charge battery, humidity causes the negative plate to discharge rather quickly.

HEAT EXCHANGER

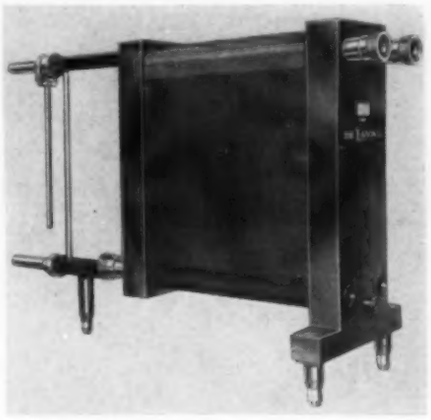
▲ A new plate heat exchanger, especially adapted to industrial process applications, wherever heating, cooling or regeneration are required, is being featured by DeLaval Separator Co.

High efficiency and lower operating costs are claimed for the new equipment because of the basic advantages incorporated into its design, construction and operational characteristics.

Outstanding features are the plates themselves. Pressed from extra heavy stainless steel stock, and including a deeply corrugated surface, they resist distortion and are actually made to withstand higher than average operating pressures. The corrugated design results in high velocity and extreme turbulence of the liquid. The heat transmission coefficient is unusually high.

Gasketing is such that all gaskets may be replaced in the user's plant without returning the plate to the factory.

The design is such as to permit thorough and effective "in-place" flush cleaning.



Liquids cannot leak between the plates nor mix with the cooling or heating medium. Cooling, heating and regeneration are readily accomplished, simultaneously, in the various sections of the unit.

Important to production engineers is the fact that because the plates are invertible, the unit may be altered from time to time to adapt it to changes in the operation.

Proper tension of the plates in the press, for maximum gasket life, can always be obtained because of the indicator marks stamped on the tightening bars. Easy tightening of the plates in the press and uniform pressure on the plates are obtained by the two-point tightening arrangement.

CREEP TEST UNIT

▲ An automatic, high temperature relaxation creep testing machine of 10,000 lb capacity, incorporating an SR-4 load cell as an electrical pick-up for load measurement, is announced by Baldwin-Lima-Hamilton Corp.

The new high-capacity machine offers the advantage of additional lower load ranges with a single pick-up device. The varying electrical output of resistance wire strain gages in the load cell is amplified to drive the pen across the recorder chart. Accuracy is within 1 per cent of reading or ¼ per cent of full scale, whichever is greater.

The standard recorder on the machine has a 10-in. wide strip chart with 100 divisions for full-scale readings of 10,000 lb, 5,000 lb, and 2,500 lb. The 150-ft chart is driven by a constant speed motor at ¼ in. per hour. Loads up to 100,000 lb per sq in. can be applied on standard 0.357-in. diameter specimens. Loading mechanism consists of a motor-driven screw jack which has a loading stroke of 2⅛ in.

Elongation of the specimen is held constant by an extensometer which has an electrical follow-up contact. Contacts operate the unloading movement for strains of approximately 2×10^{-6} in. per in. Extensometer arms are designed for use in the furnace which is mounted on the machine. Rupture of a specimen opens the control circuit and stops both loading motor and recorder.

The machine is of welded construction and has recorder and electrical

STEEL TUBING

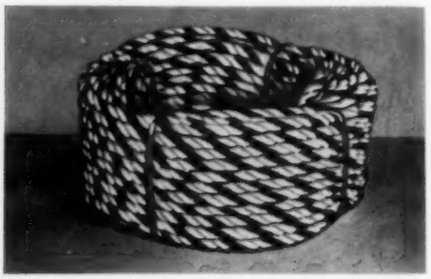
This tubing with ID fins was produced by the Babcock & Wilcox Co., of a special heat resisting stainless steel. It is used in a heat exchanger with fire on the outside and gas on the inside. At present the production of such specialties has passed the purely experimental stage and similar tubing can be produced of a number of steels in a limited size range.

LARGE GAS MAINS
are Safest with...
Bailey thermal expansion
GOGGLE VALVES
One of nature's most dependable forces—the linear expansion and contraction of steel—frees and clamps the goggle plate of these valves. Steam applied to three sets of tubes causes expansion which frees the goggle plate for swinging to either open or closed position. When steam is removed, contraction of the tubes forms a tight, safe, leakproof seal. Can be operated by hand in case of steam failure.
Made in sizes from 36" to 120" in diameter for horizontal or vertical gas mains.
WILLIAM M. Bailey COMPANY
ENGINEERS
LEADERSHIP THROUGH QUALITY
1221 BANKSVILLE ROAD
PITTSBURGH 16, PA.

controls in a cabinet mounted alongside it on a common base plate 43 in. wide and 22 in. deep. Machine height is 87 in.

PLASTIC ROPE

▲ Introduction of a plastic barrier rope, especially adapted for use in restricted areas, is announced by Industrial Products Co. Composed of two strands of yellow polyethylene



plastic, and one of black, the rope offers high visibility in addition to carrying out the standard "caution" colors.

Possessing excellent dielectric properties, the rope is not affected by oil. It will not absorb dirt or support combustion. Light and flexible it will not sag or stretch. Diameter is $\frac{5}{16}$ in.

VALVE COUPLING

▲ Recently introduced by C. B. Hunt & Son, Inc., is a valve coupling which gives the operator complete and safe control of the air line, at whatever point between the compressor and air operated device, the valve coupling is installed.

The nose piece of the jaw half of the coupling is provided with an "O" ring held in a machined groove. When the coupling is connected, the nose piece slides into the recess of the connection half of the coupling. The joint is tightly sealed by the internal fluid pressure acting on the "O" ring, but the two halves are able to swivel freely without leakage. The "O" ring is readily accessible and can be replaced easily and quickly without tools.

The jaw or valve half of the coupling which is always connected to the live air supply line, is also provided with locking jaws and a brass sleeve which is fitted on the inside with pressure sealing U-packers.

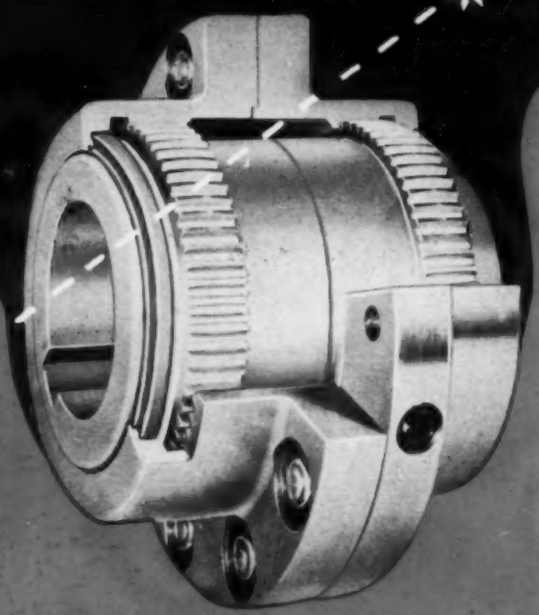
The jaws cannot be opened, and the coupling cannot be disconnected, while the sleeve is in the "On" position. Returning the sleeve to "Off and Exhaust" position traps the supply

V. R. BROWNING
MILL TYPE CRANES
TO Specification
Basically designed as required by A.I.S.E. specifications, mill type cranes built by Victor R. Browning & Co., Inc. also offer the opportunity of specifying preferences and standards prevailing in the purchaser's plant. May we have your next inquiry?
VICTOR R. BROWNING & COMPANY, Inc.
BOX 309, WILLOUGHBY (CLEVELAND), OHIO
Designers and Builders of Electric Overhead Traveling Cranes and Hoists and Electric Revolving Cranes

WALDRON

built for long life

COUPLINGS



preferred for their

7

DESIGN FEATURES

1 **ALL STEEL** construction from high grade steel forgings with fine tool finished surfaces.

2 **ONE PIECE COVER SLEEVE** is one solid forged steel unit for added safety at high speeds.

3 **AUTOMATIC LUBRICATION** with ever-present oil film between hub and sleeve to prevent friction or wear.

4 **POSITIVE SEAL** hermetically seals coupling against oil oxidation and keeps ample supply of CLEAN oil inside.

5 **LONGER LINING UP SURFACE** insures easy, accurate initial alignment and full capacity to handle any subsequent misalignments.

6 **COVER SLEEVE BEARING** prevents any added pressure to either shaft; eliminates adverse end crank action on shaft.

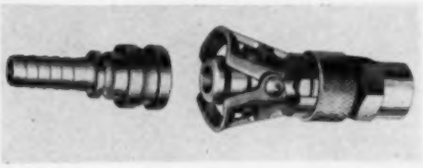
7 **LARGER BORE** permits use of smaller physical capacity for same size shaft and reduces rotating weight.

WALDRON couplings are available in sizes up to 18" shaft diameter. We specialize in furnishing couplings for unusual applications and services. We would be pleased to send you our latest bulletin 551 upon request.

JOHN WALDRON
CORPORATION
New Brunswick, N. J.
Since 1827

Sales Representatives In Principal Cities

air in the sliding sleeve stopping its flow. It also opens ports through which air on the connection or tool side can be exhausted, thus preventing damage from air tools which are not properly exhausted. Additionally it avoids the danger of the hose end whipping around discharging high



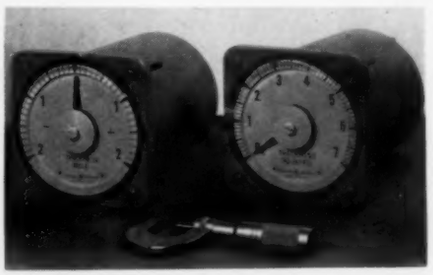
pressure air to the atmosphere, and permits the jaws to be opened so the coupling can be disconnected. A 90 degree twist of the brass sleeve, when it is in "Off and Exhaust" position, locks it in this position, and permits the hose to be moved around without danger of accidentally opening the valve, and exhausting live air to the atmosphere.

These valve couplings are available in ¼ to ¾ in. sizes with hose, or male or female pipe threads; and can be used with air to 250 psi.

INSTRUMENTS

▲ Two new integrating instruments, one current-integrating and the other current-squared integrating, have been announced by the General Electric Co.

Designed to reduce laborious statistical analysis to a simple slide rule calculation, the instruments are designed for the solution of quality control problems encountered by the manufacturers of yarn, wire, strip



metals, photo film, rope, plastics and similar products in continuous moving processes, according to G-E engineers.

They differ from conventional indicating instruments in that they contain no control springs, and have a special mechanism that provides a high degree of damping.

When current ceases to pass through the coils, the instruments' pointers stop instantly thus affording

LIGHT IN THE NIGHT...

Spearing across the snows
of Canada shines this headlight.
But for refractory brick,
the arc wouldn't spark to flash
the headlight, the stainless
steel with which the car is built
would not exist . . . the trucks
she rides on, the motors and the
generators, even the glass . . .
depend for their existence upon
quality refractories
such as Grefco supplies
the world.

Budd Rail Diesel Car on the
Canadian Pacific Railway

GENERAL REFRACTORIES COMPANY

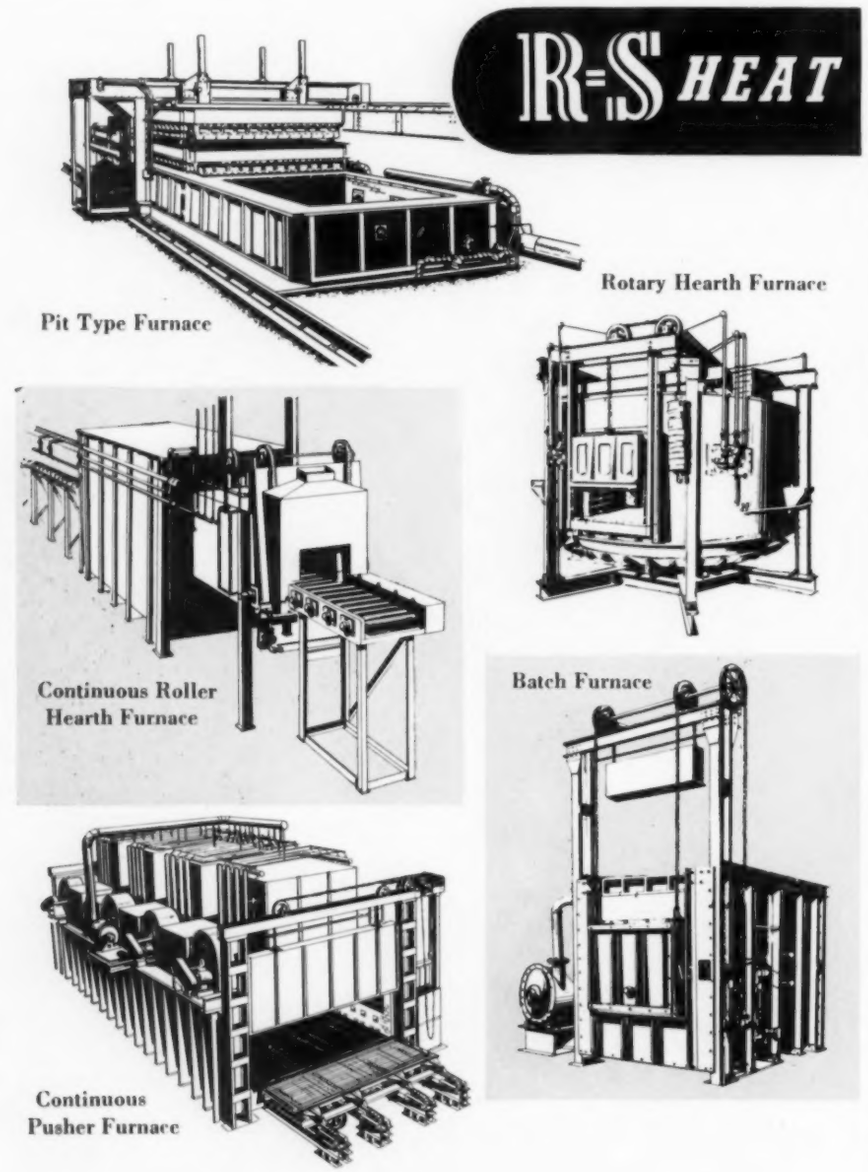
GENERAL
REFRACTORIES
COMPANY
Philadelphia

Products of fame . . . wherever there's flame

unusually accurate readings. Since the lead-in spirals contain no appreciable torque, special control circuits are furnished to reset the instrument pointers to zero.

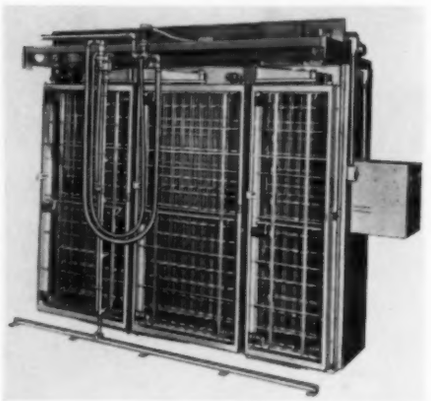
The current integrating instrument has a permanent-magnet moving-coil driving mechanism. The speed of its pointer at any instant is proportional to the current going through the coil at that instant. Rated from minus 85 to plus 85 milliampere-seconds, the instrument has an accuracy or plus or minus two per cent of full scale for integrating random-varying currents lasting over a period of two minutes. The device responds adequately to instantaneous current values as low as 0.03 milliamperes and to peaks as high as six milliamperes.

The current-squared integrating instrument has a dyanometer-type driving mechanism. The speed of its pointer at any instant is proportional to the square of the current passing through it at that instant. This instrument has an accuracy rating of plus or minus three per cent for integrating ordinary random-varying signals lasting over a period of two minutes. It responds adequately to instantaneous current values ranging from 1.5 to 30 milliamperes.


R-S HEAT
Pit Type Furnace
Rotary Hearth Furnace
Continuous Roller Hearth Furnace
Batch Furnace
Continuous Pusher Furnace
R-S
QUALITY FURNACES SINCE 1908
R-S FURNACE TYPES
Hi-Head ● Batch ● Rotary Hearth ● Continuous Belt Conveyor ● Continuous Chain ● Continuous Pusher ● Continuous Pusher Tray ● Pit ● Continuous Roller Hearth ● Car Hearth

PRECIPITATOR

▲ American Air Filter Co., Inc. has redesigned their electronic precipitator to provide semi-automatic reconditioning of the collector plates. The recently developed Type H washer washes the collector plates with water sprays and recoats them with a dust holding adhesive. The entire operation is automatic after a starting button is pushed.



The washer consists of a vertical header attached to a carriage that travels on an overhead trackway extending the full width of the precipitator. The header comprises separate water and oil lines with uniformly spaced nozzles. The assembly moves across the precipitator twice on the washing cycle and, after a five minute drying period, sprays the collector plates with adhesive.

The flat spray nozzles are placed at a five degree angle to the vertical plane of the collector plates thus insuring thorough penetration of the plate assembly. The Type H washer is optional equipment available for all sizes larger than 6 ft. high by 6 ft. wide.

THREAD COMPOUND

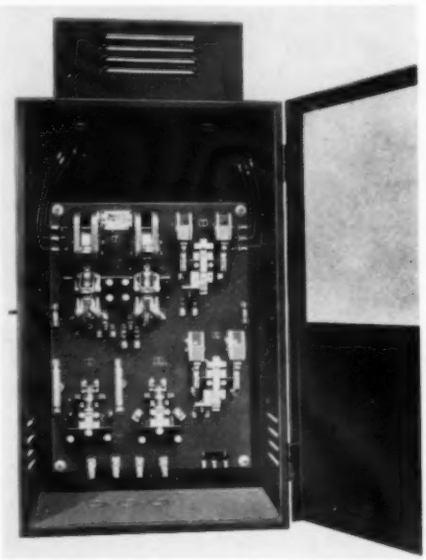
▲ Protection against the welding action of threaded connections subjected to prolonged exposure to extreme heat, is offered by a new thread

compound. Developed by Crane Packing Co. it is known as "Thred-Gard," and is said to eliminate seizing and galling at operating temperatures up to 1200 F.

The compound is non-hardening and acts as a lubricant to allow easy disassembly of threaded connections, even after lengthy service under the most severe conditions. Not only is dismantling time greatly reduced, but damage to stud, bolt, pipe joint and plug threads is prevented, thus permitting their re-use many times over.

CONTROLLER

▲ A new high speed release automatic-discharge controller for deep-type lifting magnets is announced by the Electric Controller & Mfg. Co.



The discharge-time of this high speed controller is about one-half that of a standard magnet controller and reduces the round-trip time of a magnet-crane by about 10 per cent.

This new controller, known as the type DLM-265-A, is used with the standard two-position, "Lift-Drop" operator's master switch.

INDUCTION MOTOR

▲ A new induction motor, designed to offer users longer motor life, greater flexibility in application, and higher reliability as well as decreased size has been announced by the Westinghouse Electric Corp. The unit has improved ventilation, better insulation, a more efficient and better protected bearing, and in addition is quieter and smaller per horsepower, conforming to the new NEMA standard dimensions. It is available in three enclosures: totally-enclosed fan cooled, totally-enclosed non-ventilated, and dripproof.

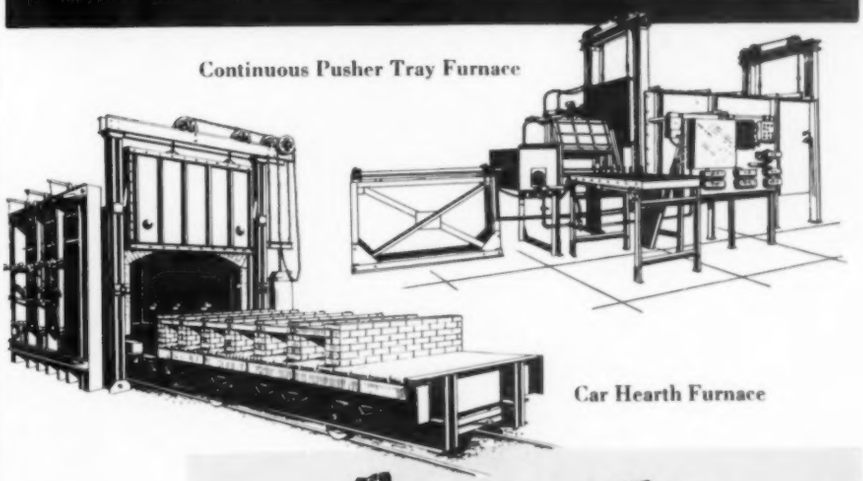
INDUSTRIAL TV UNIT

▲ For industrial television installations where a smaller camera having high resolution and using lower lighting levels is desirable. Diamond Power Specialty Corp., has developed a new camera that is securing exceptional results. This camera, model 300-BV, can be used instead of or is interchangeable with the standard "Utiliscope" Model 300-B camera.

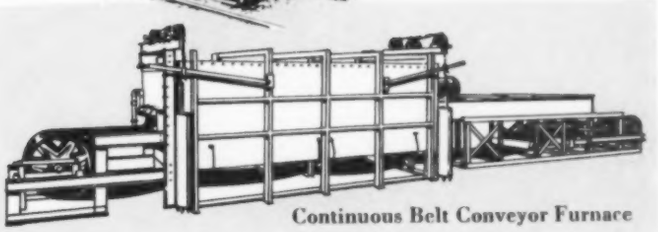
The new unit is simple to operate and requires no trained operating personnel. Another feature is the easy accessibility for servicing. The Model 300-BV also has the basic features of operational stability and constructional ruggedness that are characteristic of the Model 300-B camera.

TREATING FURNACES

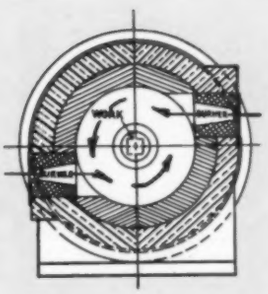
Continuous Pusher Tray Furnace



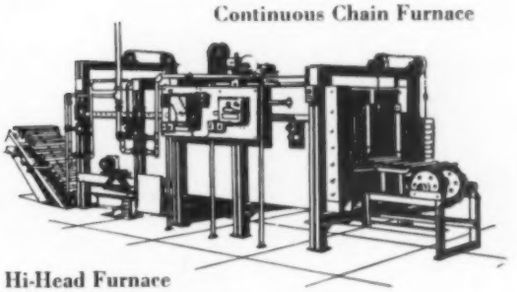
Car Hearth Furnace



Continuous Belt Conveyor Furnace



Continuous Chain Furnace



Hi-Head Furnace

R-S FURNACE CORP.
4555 GERMANTOWN AVENUE
PHILADELPHIA 44, PENNSYLVANIA

A SUBSIDIARY OF
HARDINGE COMPANY, INC.

R-S
QUALITY FURNACES SINCE 1908

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and

get this BIG BONUS

Surplus OXYGEN

- Top blast conversion
- Flame enrichment • Desiliconizing
- Decarburizing • Hot top heating

An *Air Products* Multiple Generator Lease Installation will enable you to:

- **Save many thousands of dollars every year on *existing* oxygen requirements**
- **Improve technology thru experiments with *surplus* oxygen**

Here's how it works. You cut costs of meeting basic oxygen requirements because you "make your own" . . . *eliminate* transportation and handling costs. You produce *practical* experimental oxygen because your installation affords a substantial amount of *surplus* capacity.

This allows you to produce extra oxygen at such a low cost it makes feasible promising experiments you may have considered too expensive.

Practical experimental oxygen is just one of the many "extras" you get when you cut costs with an *Air Products* Multiple Generator Installation. Equipment can be adapted to also produce by-product nitrogen and argon at high purities . . . if you need them now or ever want them. Let us show you the possiblities for your company!

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Dept. P, Box 538, Allentown, Pa.

Air Products INCORPORATED

MULTIPLE GENERATOR LEASE INSTALLATIONS

Low Cost Oxygen...Nitrogen...Argon

- **No investment for equipment**
- **Rentals 100% tax deductible**
- **Service maintained by *Air Products***
- **Flexibility to meet varying requirements**

The "Utiliscope" (wired television) has a wide variety of industrial and commercial applications. The camera can be placed in practically any location—no matter how remote, dangerous or inaccessible. One or more viewing screens are located wherever convenient to the operators. The many applications include: watching water level and furnace conditions in big power boilers; observing interiors of steel heating furnaces; viewing dangerous and destructive tests; guarding plant gates; supervising manufacturing operations from a distance; inspecting sensitized film.

MEASURING UNIT

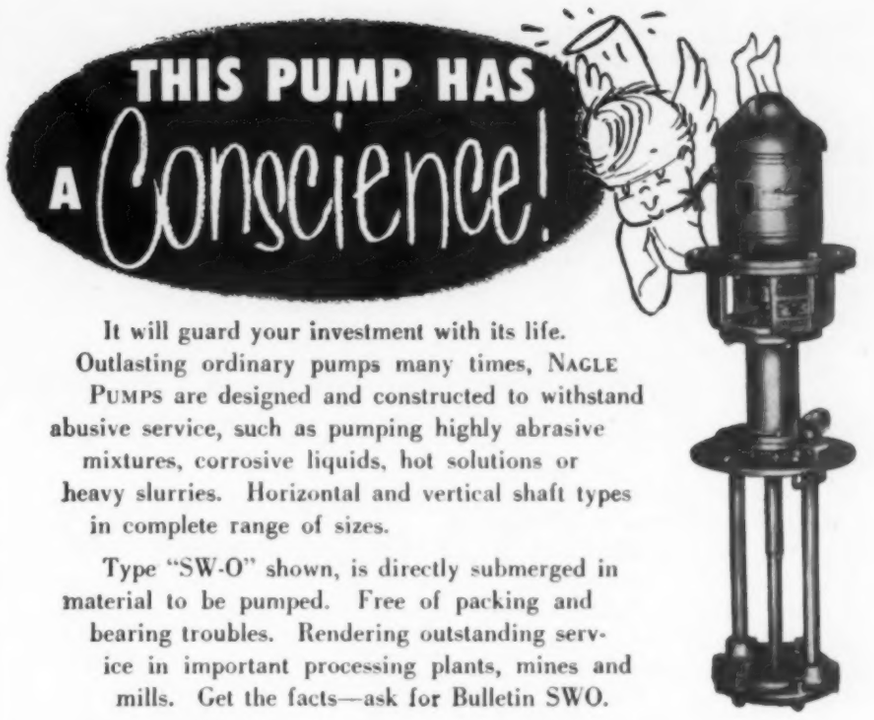
▲ A new three-part pneumatically-operated instrument system known as the Metagraphic System, has been announced by the Bristol Co. In these instruments each of the basic functions performed is packaged separately. Units are: a transmitter, a receiver (recorder or indicator), and a controller. Each unit can be installed on the process at the point where it operates best, thus providing a high degree of flexibility of application.

These instruments measure, indicate, record, and control pressure, vacuum, temperature, liquid level, differential pressure, and flow.

A universal 3-15 psi air pressure signal interconnects the three units no matter what variable is being transmitted. This makes the components universally interchangeable. (3 to 18 psi signal span also available). The new receivers and controllers are designed for full plug-in service. Strip-chart recorders, and indicators are quickly interchangeable without loss of signal or control. Design features include continuous valve position indication requiring no switching to get reading, "bumpless" manual-automatic transfer by simply matching pointers, and a set-point regulator of high-output capacity.

Controllers are offered in five modes of control, including on-off, proportional, proportional plus reset, proportional plus derivative, and proportional plus reset plus derivative.

The entire system has been designed to reduce design engineering problems, to make it possible to do all maintenance work in the shop,


THIS PUMP HAS
A Conscience!
It will guard your investment with its life. Outlasting ordinary pumps many times, NAGLE PUMPS are designed and constructed to withstand abusive service, such as pumping highly abrasive mixtures, corrosive liquids, hot solutions or heavy slurries. Horizontal and vertical shaft types in complete range of sizes.
Type "SW-O" shown, is directly submerged in material to be pumped. Free of packing and bearing troubles. Rendering outstanding service in important processing plants, mines and mills. Get the facts—ask for Bulletin SWO.
NAGLE PUMPS
NAGLE PUMPS, INC.
1263 CENTER AVE., CHICAGO HEIGHTS, ILL.
PUMPS FOR ABRASIVE AND CORROSIVE APPLICATIONS

and to keep a process operating with a minimum of "down time" due to instrument maintenance.

GRINDING MACHINE

▲ Four models of a new contact grinding and polishing machine are among several new machines being made exclusively for the Curtis Machine Corp., by an affiliate company in Germany.

The four models, are all completely integrated, double end, pedestal type machines for abrasive belt contact grinding and polishing.

All models have approximate 18-in. belt adjustment permitting use of one size belt with various diameter contact wheels. Either two belts, or a belt and grinding wheel, or buff can be employed. The machines are equipped with positive belt tracking devices and spring loaded belt tensioning. Dust proof ball bearings are used on all machines. Models are also equipped with special type belt attachments that can be easily positioned vertically and swiveled to horizontal. This unique type of mounting permits the backstand extension to swivel 90 degrees with maximum utilization of floor space. The models can be furnished with or without these attachments.

The machines are powered by electric motors with hp varying among the four models. Speed and surface speed of the abrasive belts vary accordingly.

This machine, in all of its models, has been designed for top performance, and by providing for either vertical or horizontal operation, a minimum of floor space is required.

REVERSING SWITCH

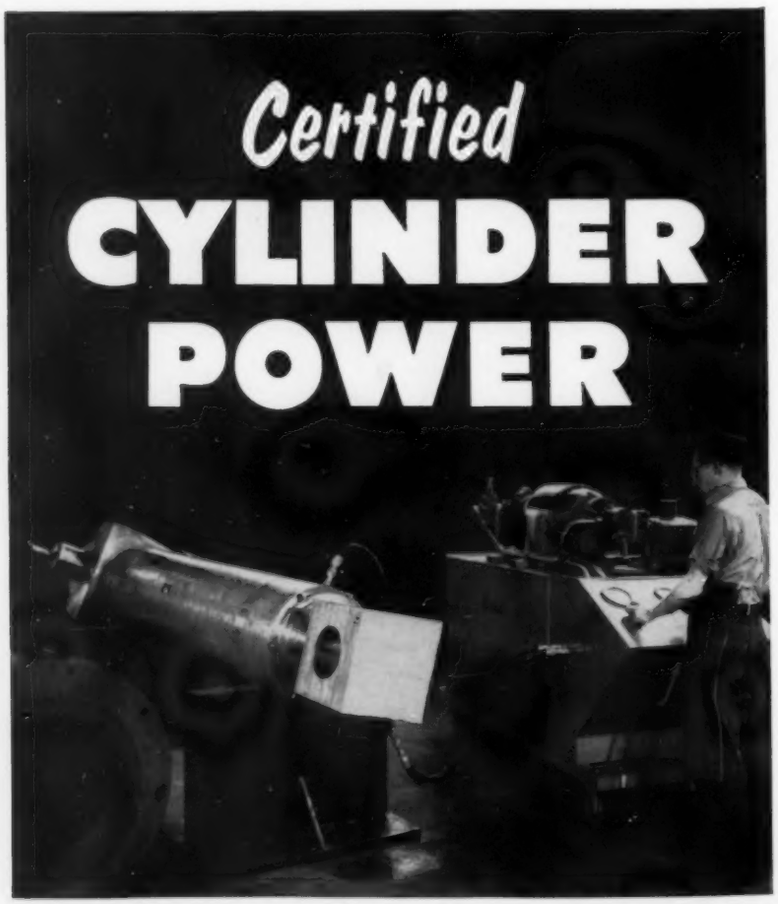
▲ A new heavy duty double pole, double throw switch for reversing high currents at low voltage has been announced by Columbia Electric Mfg. Co. It is rated 3,000 amperes and is the latest addition to an existing line of reversing switches rated 300, 500, 1,000 and 2,000 amperes for use on direct current up to 15 volts.

This 3,000 ampere cam type switch is designed primarily to reverse the current flowing through a plating tank. When specified it can be furnished for use as a series-parallel switch for double commutator generators. The unit consists of two ebony asbestos panels mounted on angle iron supports, with manually operated handle of sufficient leverage for ease of operating the entire switch mechanism. By placing the handle in a neutral position the line current can be disconnected.

A total of 16 heavy duty toggle-switches are mounted on the panels, eight for each current direction. The cam action of the switch mechanism assures positive contact pressure. Contact surfaces are automatically cleaned by the inherent wiping action of the laminated copper moving contacts. Switch is rear connected, and is furnished complete with reversing jumpers and four terminals for incoming bus bars. Stationary contacts are readily replaceable.

MOTOR

▲ Development of a completely new motor with numerous revolutionary features and conforming in every particular with NEMA specifications



Testing Anker-Holth Hydraulic Cylinder to be used on a metal stretch forming press. Cylinder on test is 16″ bore, 69½″ stroke, for 3000 psi operating pressure. Tested at 4500 psi.

Thorough testing of Anker-Holth Cylinders assures you dependable power

● Every Anker-Holth Cylinder . . . large and small . . . is tested at 150% of working pressure with the latest completely-filtered testing equipment. Anker-Holth testing facilities include portable units such as the one shown . . . also stationary equipment for pressures up to 10,000 psi.

This is one of many safeguards in manufacturing to assure you top performance and dependability in Anker-Holth Cylinders. There's a type and size of cylinder to match *your* need. Anker-Holth engineering know-how is available to help solve your power motion problems. Call or write ANKER-HOLTH DIVISION of The Wellman Engineering Company. Dept. E-8 2723 Conner Street, Port Huron, Michigan.

FREE: *Bulletin on complete line of ANKER-HOLTH products.*

Anker-Holth
ENGINEERED CYLINDER POWER
WELLMAN

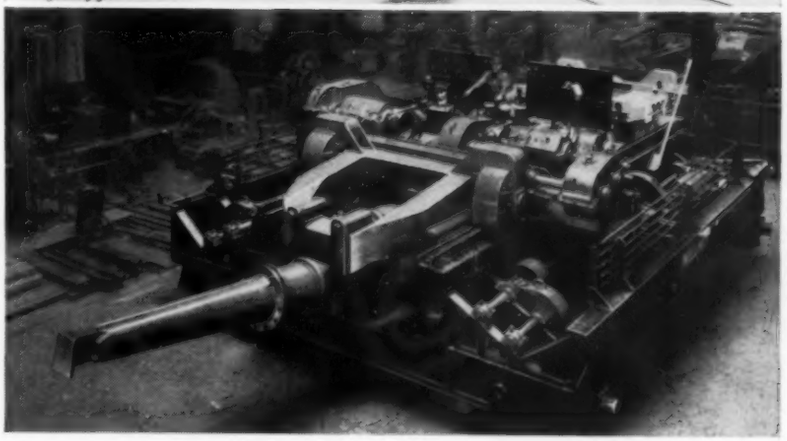
Division of THE WELLMAN ENGINEERING COMPANY

Wellman will build it

Special Cranes
Charging Machines
Ore Unloaders
Forging Manipulators
Car Dumpers
Gas Flue Systems
Gas Reversing Valves
Coke Pushers
Mine Hoists
Skip Hoists
Ore and Coal Bridges
Clamshell Buckets

Wellman charging machines

efficiently serve open-hearth furnaces



Above:
Wellman High-Type, Open-Hearth Charging Machine.

Below:
Wellman Low-Type Charging Machine.

● Wellman Charging Machines for open-hearth furnaces are available in the high-type shown above and in low-type shown in inset. These machines are typical of all Wellman equipment. They are backed by more than a half-century of experience in designing and building for efficient performance. You can have utmost confidence in Wellman recommendations.

THE WELLMAN ENGINEERING COMPANY

7010 CENTRAL AVENUE · CLEVELAND 4, OHIO

is announced by U. S. Electrical Motors Inc. By increasing precision of manufacturing processes, holding tolerances to closer limits and improving the electrical characteristics, this new motor, designated as Uniclosed, Type H, is more compact than previous models. One outstanding feature is its complete drip-proof design without increased cost.

The frame is solid, one-piece cast iron and the stator is pre-wound. Frame sizes 182-184 are now available. By utilizing the interior space to better advantage, the motor is built more compactly so that the same horsepower can be embodied in less space.

The end brackets are of entirely new design with air intakes so arranged as to prevent intrusion of water, yet allow liberal air flow into the motor for 2-way ventilation. Baffles of an entirely new design within the air vestibules of the end brackets prevent splashings from entering and coming in contact with the windings.

This new motor in its various sizes meets the same standards as its former type in temperature rise, torque, etc. Overload capacity has not been reduced. The slot design of the laminations has been improved and the asbestos-protected windings, an exclusive feature, have been reinforced and strengthened by the addition of Mylar laminations.

Another desirable feature is the split dome, cast iron terminal box which makes the leads more accessible. A stainless steel data plate set above the box presents a rustproof surface with legible instructions that can never be defaced. Air impeller blades on the rotor ends have been redesigned with curved edges to permit more quiet operation.

All castings are normalized. Lubriflush lubrication of the bearings provides means of replacing old grease with new without the necessity of disassembling the motor or disturbing the bearings. The air intake is so designed to avoid pickup of dirt and dust from the floor.

TITZEL

OPEN HEARTH EQUIPMENT

STOPPER RODS
DRYING OVENS

and

HOLDING OVENS

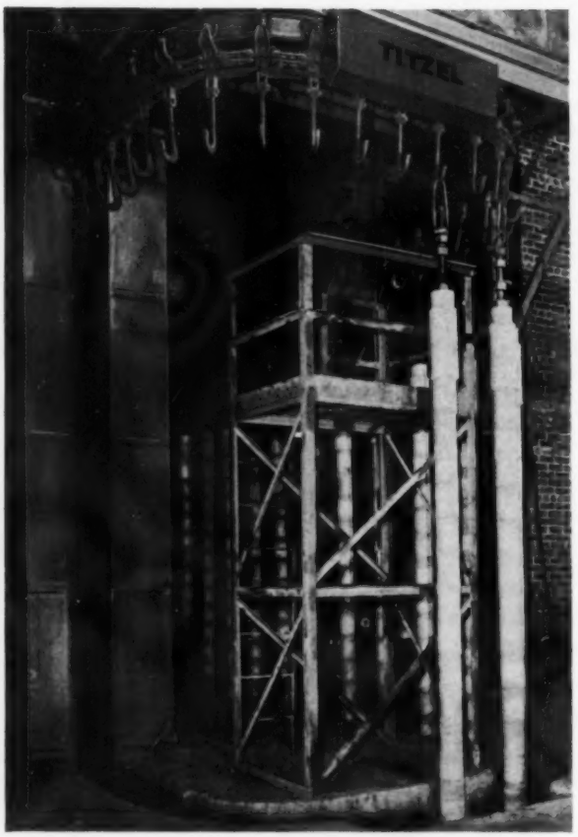
also

JIB CRANES
FOR SPOUTS

LADLE REPAIR

BUTTON
BURNING
CRANES

SPECIAL
EQUIPMENT



TITZEL ENGINEERING, INC.
PITTSBURGH 22, PA.

ABRASIVE MATERIAL

▲ A new non-clogging open-mesh abrasive material, designed especially for sanding operations where loading or glazing is a problem, is now in full production and is commercially available in a wide variety of shapes and sizes from the Carborundum Co.

Extensively field tested in the sanding of ferrous and nonferrous metals, wood and paint undercoats and sealers, the material called "Sand Screen" has been found to give 7 to 15 times longer life than conventional coated abrasives.

The new sanding, screen-like abrasive is coated uniformly on both sides, with silicon carbide grain. Its unique, open-mesh construction reduces loading to a minimum, by permitting sanding residue to flow freely through the numerous openings, and also enables the material to be used on both sides. Through a recent development in the manufacturing process, it is now possible to retain the sharpness of the abrasive grain on both sides.

It can be used wet or dry, for both machine and hand sanding operations. It comes in full sheets, cut sheets and discs, in grit sizes of 180 and finer. It can also be furnished in standard 50-yd rolls up to 18-in. wide.

The new material can be used flat or can be folded to any desired size for hand sanding. It can also be creased and torn readily into any desired width from a 9 x 11-in. sheet.

It pays to buy USG® BRUSHES

For crane motors — mill motors — tin line generators
— for all rotating electrical equipment —
USG BRUSHES are best.

Our brush engineers can analyze and solve those tough application problems. Give our experienced representatives a chance to prove it with a performance test.

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ASK FOR OUR CATALOG

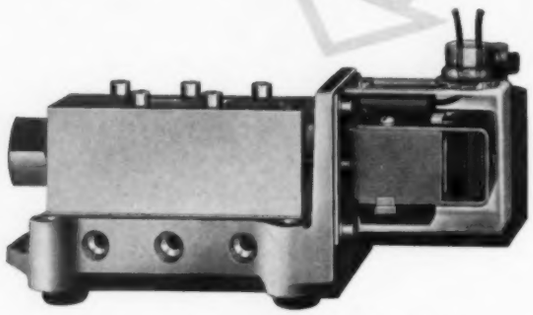
178

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

Quick-As-Wink
AIR AND HYDRAULIC
Control Valves

FEATURE THIS MONTH



1/8" and 1/4" Single Solenoid Valves

They'll give you up to 300 cycles a minute
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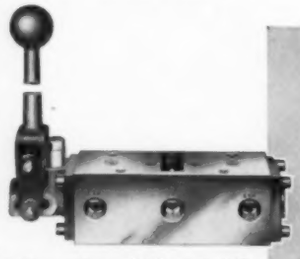

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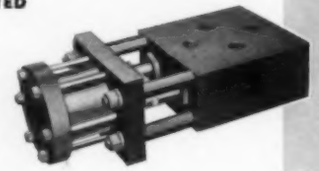

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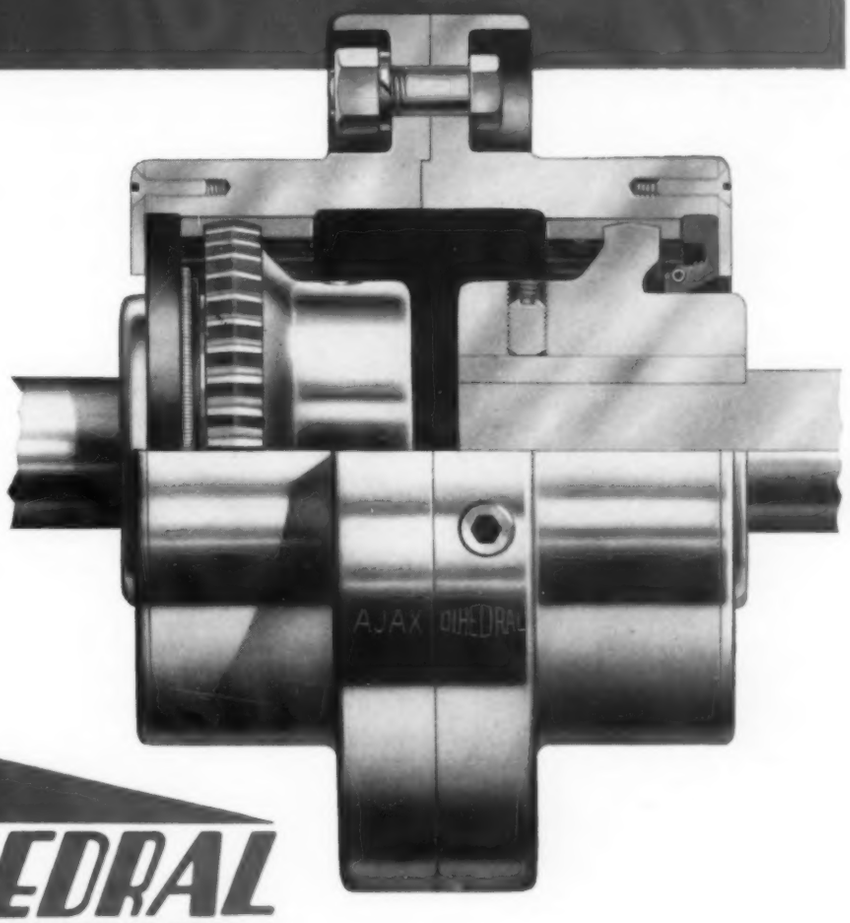

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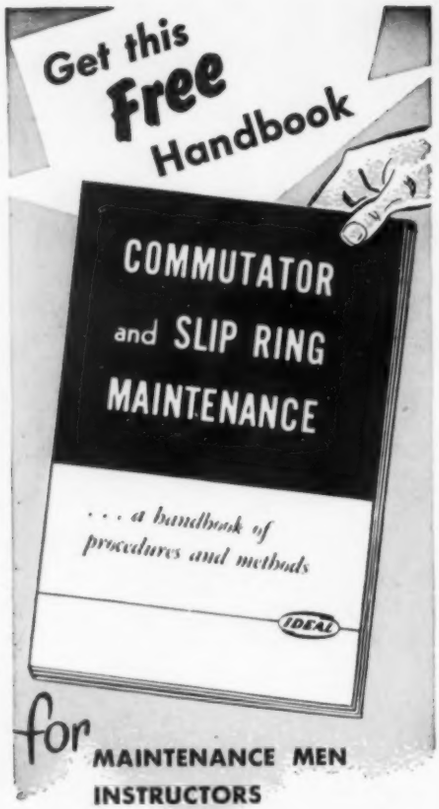

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▲ **"Materials and Processes,"** by James F. Young, has recently been published by John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 6 x 9-in., 1074 pp., cloth bound, price $8.50. This is a second edition which provides in one volume the related information needed to apply the engineering fundamentals of materials and processes to the design, production and control of products. It covers metallic and nonmetallic materials in manufacturing processes. This second edition is expanded by 50 per cent over the first edition and incorporates changes in practices in the last ten years. It is one of a series written for the General Electric educational program. The author is a consultant on the staff of the vice president of engineering of the General Electric Co.

▲ **"Formulas for Stress and Strain,"** by Raymond J. Roark has been recently published in a third edition by the McGraw-Hill Book Co., 330 West 42nd Street, New York 36, N. Y., 6 x 9-in., 382 pp., price $7.50. This book is a working handbook for engineers who are concerned with machine and structural design. It may also be used as an auxiliary textbook for courses in stress analysis. The book has a great deal of experimental data and empirical formulas and tables of coefficients for stress and deflection calculations. It has wide coverage and material is presented in a very usable and convenient manner which makes it easy to find the item which is of interest.

▲ **"Mechanics of Materials,"** by Seibert Fairman and Chester S. Cutshall, published by John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., cloth bound, 6 x 9-in., 420 pp., price $5.75. This book covers fundamentals for the average student and concentrates primarily on the basic principles of the mechanics of materials. Numerous problems are included.

▲ **"Tool Engineers' Data Book,"** by Gerhard J. Gruen, is a recent book published by Reinhold Publishing Corp., 330 West 42nd Street, New York 36, N. Y., 6 x 9-in., cloth bound, 220 pp., price $5.50. This book gives easy and rapid access to the tables, formulas, constants and specifications needed by the practicing tool engineer

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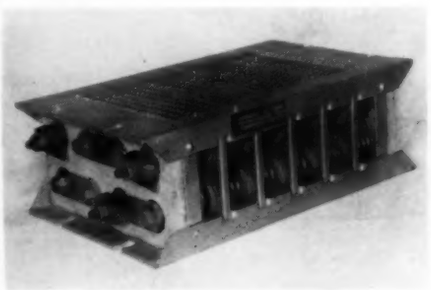

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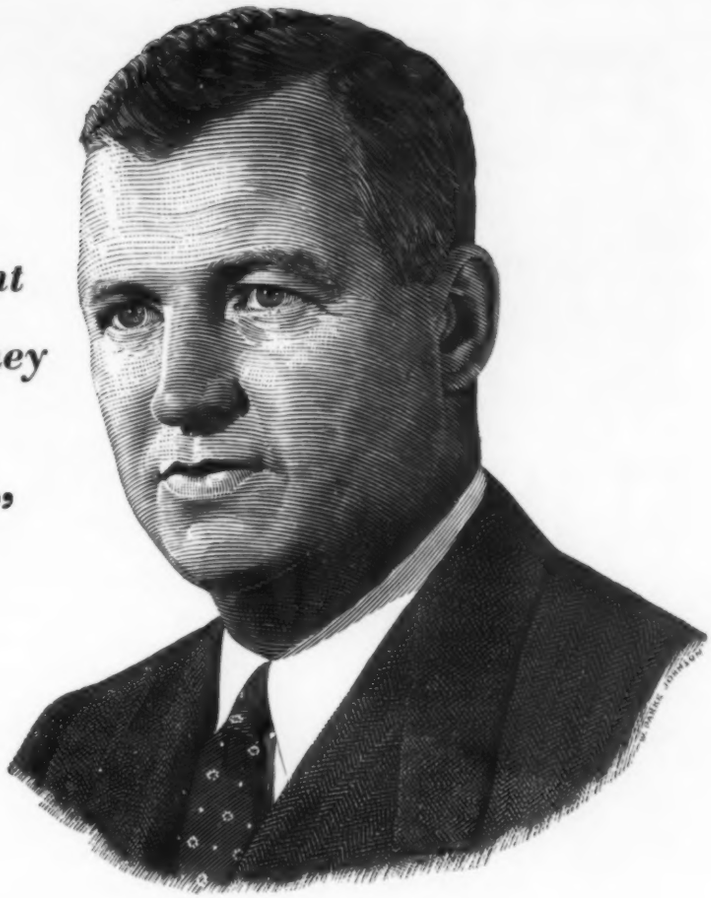

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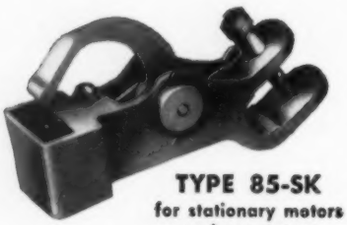

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and designer. Explanations of theoretical matter have been eliminated from this volume which gives extensive data on general properties of alloys, heat treatment, spot identification of metals, alloys and plastics, blank size diameters for shells and other tables of data.

▲ **"Aluminum in Iron and Steel,"** by Samuel L. Case and Kent R. Van Horn, was recently published by John Wiley and Sons, 440 Fourth Avenue, New York 16, N. Y., cloth bound, 6 x 9-in., 478 pp, price $8.50. This book is the first in the new series of "Alloys of Iron Monographs" published for the Engineering Foundation, with Frank T. Sisco as director and editor. The series will eventually include a critical summary of all the important research work and published information on each of the most important elements used in the manufacture of steel. This book discusses in great detail the use of aluminum as a deoxidizer, and also as an element in iron and steel. The phenomena of inclusion formation, grain size, notch sensitivity and aging are extensively treated in the book.

▲ **"Plane Surveying,"** by Frank R. Theroux, Lisle A. Smith and Leo V. Nothstine was recently published by Pitman Publishing Corp. in New York, 4¾ x 7½-in., flexible cover, 408 pp. This is a second edition of this popular surveying text and brings up to date the latest practices in plane surveying.

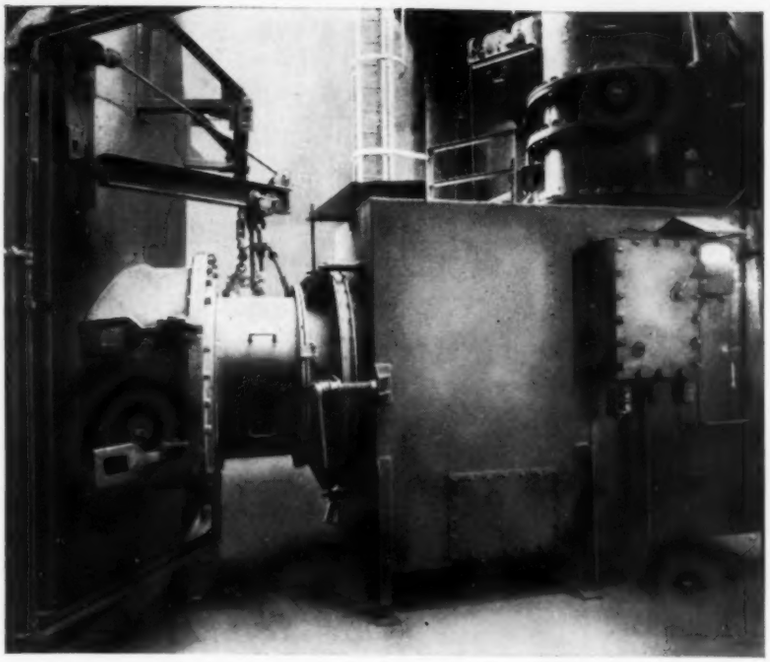
▲ **"Atmospheric Pollution, Its Origins and Prevention,"** by A. R Meetham, was recently published by Pergamon Press Ltd., Two Studio Place, Kinnerton Street, London, S.W., England, 5½ x 8½-in., cloth bound, 268 pp, price $4.90. It has been estimated that over 8,000,000 tons of atmospheric pollution are produced each year in Great Britain from the combustion of coal and its derived fuels. This pollution is the main subject of the book which is directed at public health officials, smoke and sanitary inspectors, engineers and law-making bodies. A number of means for producing and preventing such pollution is discussed in the book. Book also goes into detail on the various sources of pollution.

▲ **"ASTM Standards on Petroleum Products and Lubricants with Related Information"** was recently published by the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 890 pp, 6 x 9-in. This book brings together in a compact form most of the ASTM standards, test methods and specifications used in the POL field.

▲ **"NEMA Standards for Electrical Insulating Varnishes, Publication No. IV 1-1952,"** is the first publication which NEMA has issued on the subject of electrical insulating varnishes. It contains information concerning the specific gravity, viscosity, drying time, non-volatile content, oilproofness and dielectric strength of a number of types of varnish. Copies are available from NEMA, 155 East 44th Street, New York 17, N. Y., at $2.50 each.

▲ **"Protective Atmospheres,"** by A. G. Hotchkiss and H. M. Webber was recently published by John Wiley and Sons, 440 Fourth Avenue, New York 16, N. Y., 6 x 9-in., cloth bound, 342 pp, price $7.00. This book was written to assist individuals who supervise manufacturing operations and metallurgists to obtain a practical understanding of the various phases of protective atmospheres. The book gives information on selecting the best atmospheric gases for given jobs and in applying and using them in the best manner to produce the desired results. The book is based upon a series of articles entitled "Protective Atmospheres in Industry" which was published in the General Electric Review. Authors are in the Industrial Heating Dept. of the General Electric Co.

▲ **"Ferrous Analysis — Modern Practice and Theory,"** by E. C. Pigott, was recently issued by John Wiley and Sons, 440 Fourth Avenue, New York 16, N. Y., cloth-bound, 6 x 9-in., 690 pp, price $12.50. This is a second edition of a book first published in 1942 under the title "The Chemical Analysis of Ferrous Alloys and Foundry Materials." The author is located in Sheffield, England, and the book covers extensively British and European practice. However, it includes sections on the modern techniques in analyzing components in steel such as the various absorption meters and spectographic procedures. Detailed treatment is also given on methods of determining hydrogen, nitrogen and oxygen. Book is primarily concerned with the type of analysis made in the steel plant and not that made in the laboratory.



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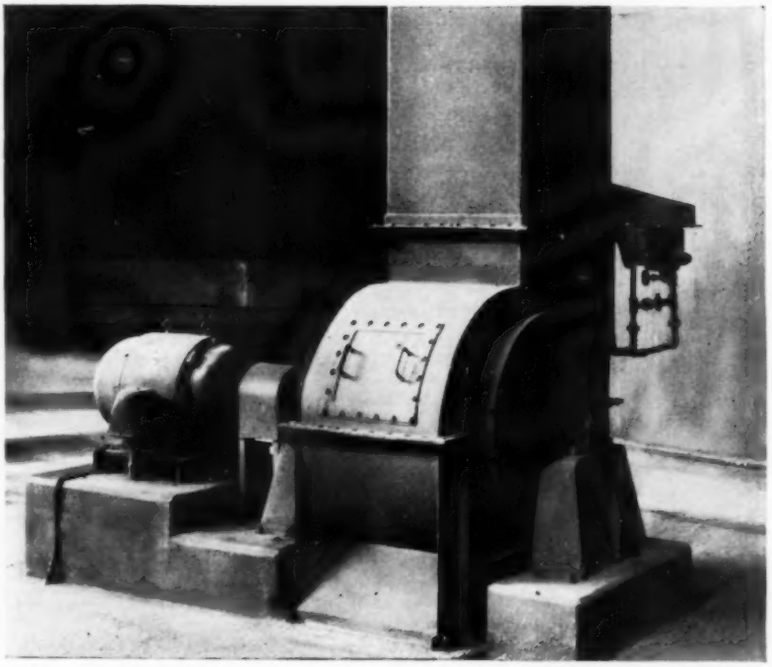

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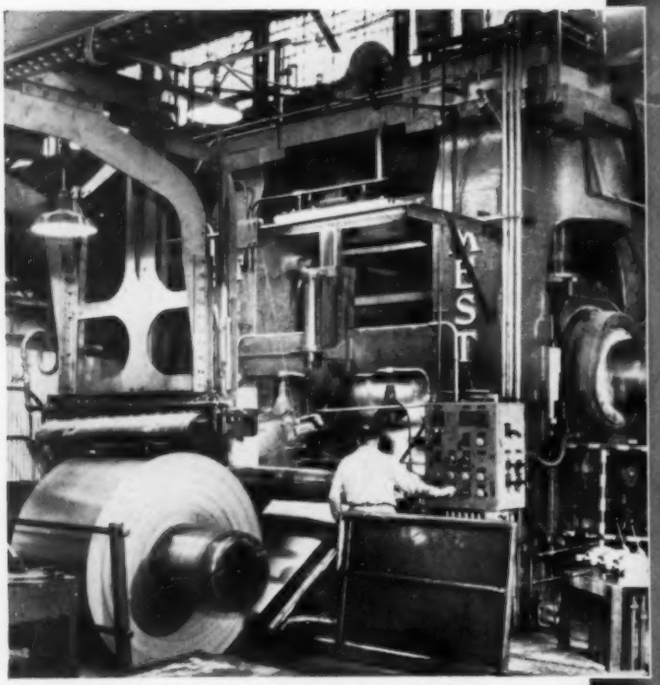

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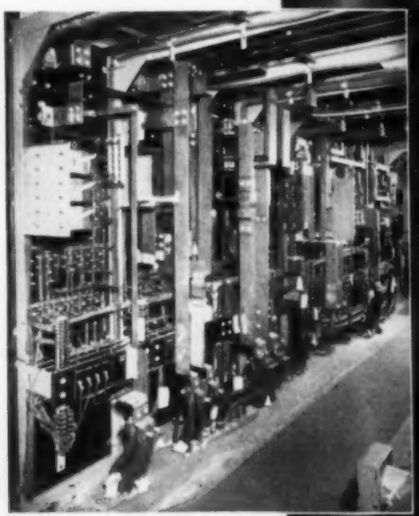

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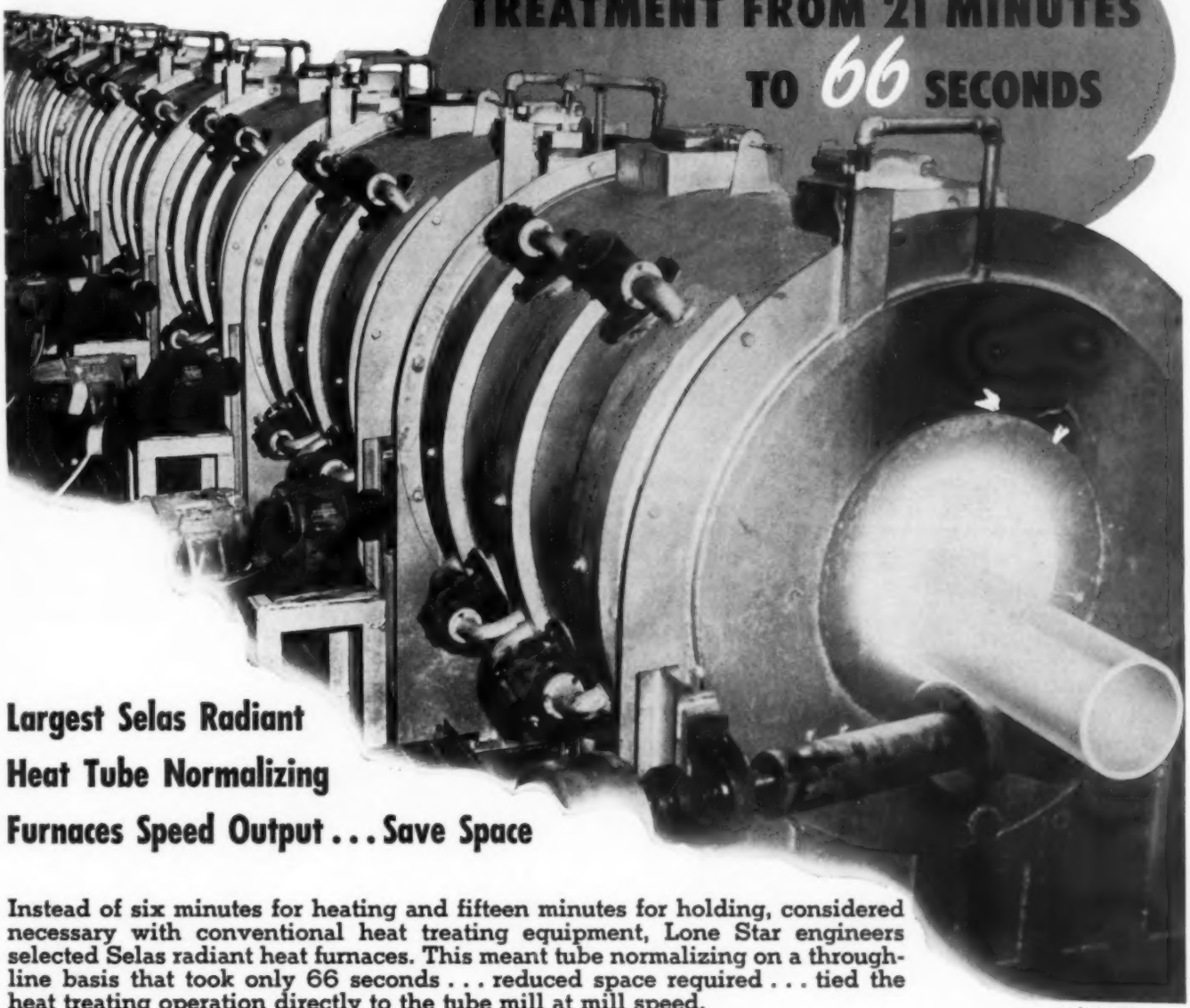

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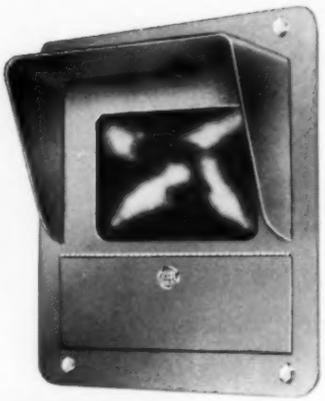

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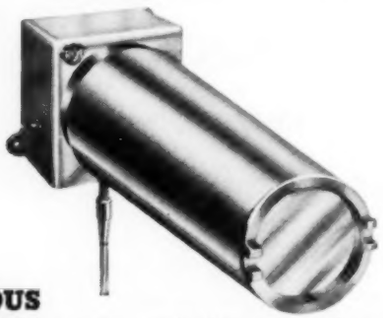

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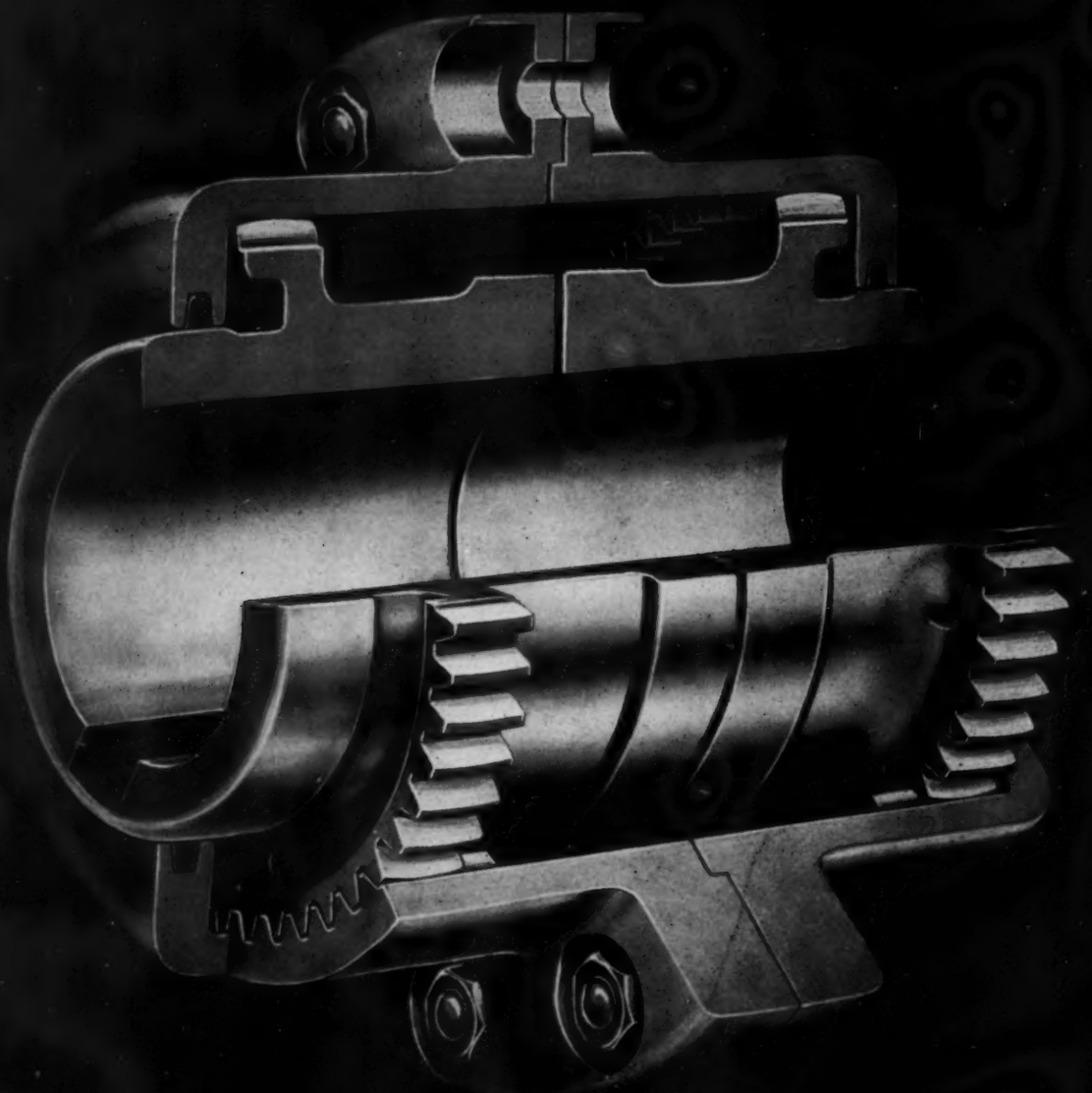

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FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.

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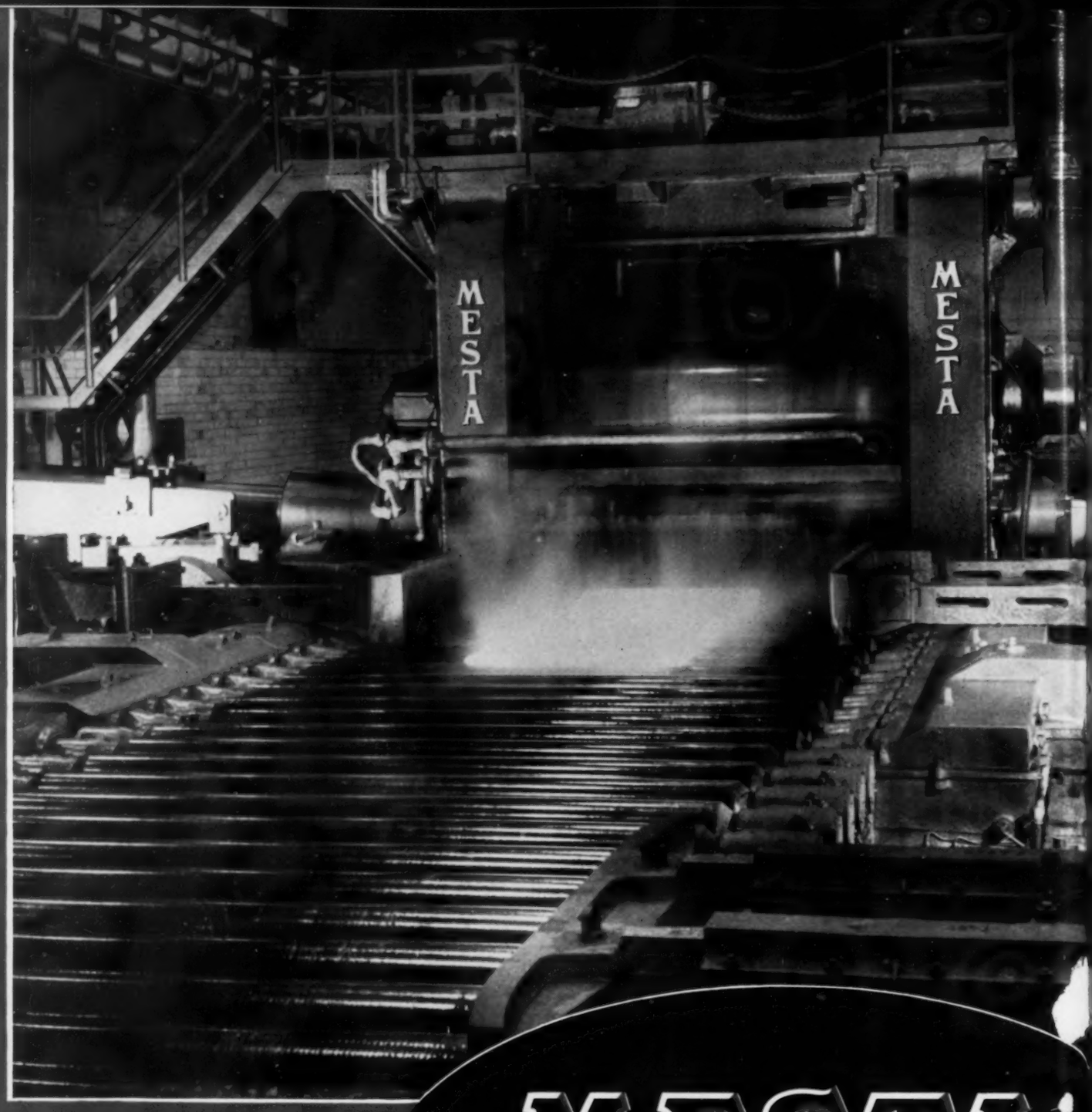

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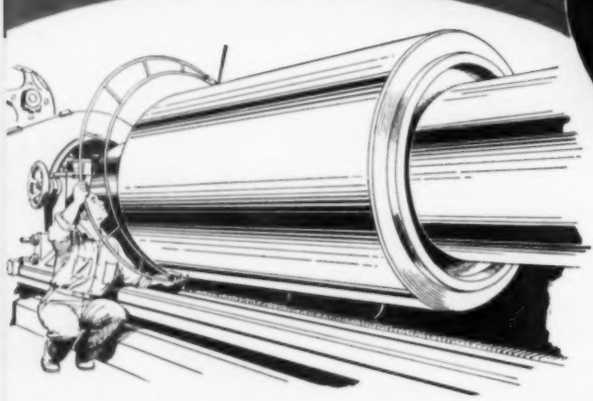
REVERSING PLATE MILL

MESTA
PLATE MILLS



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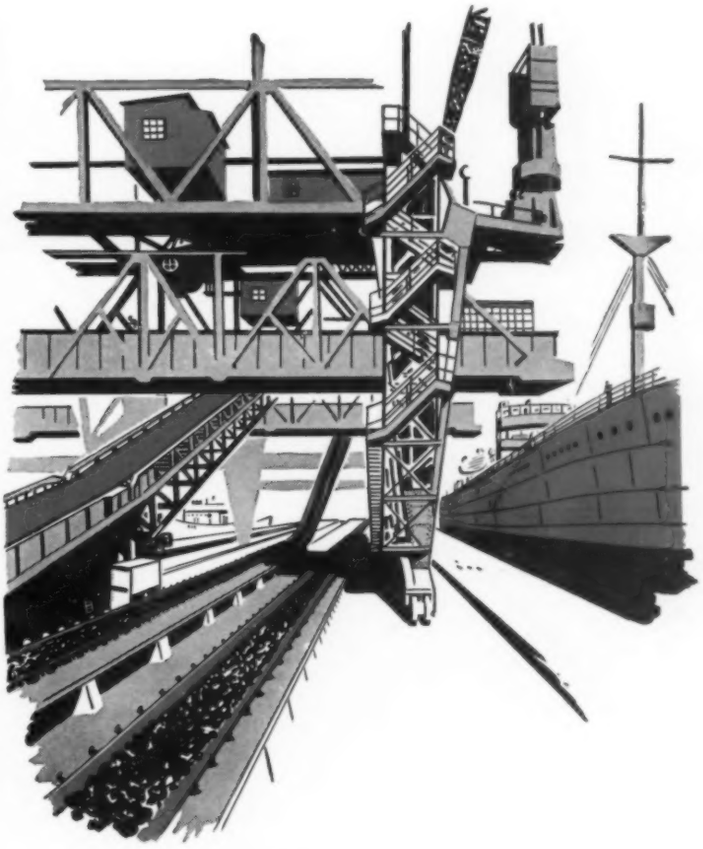
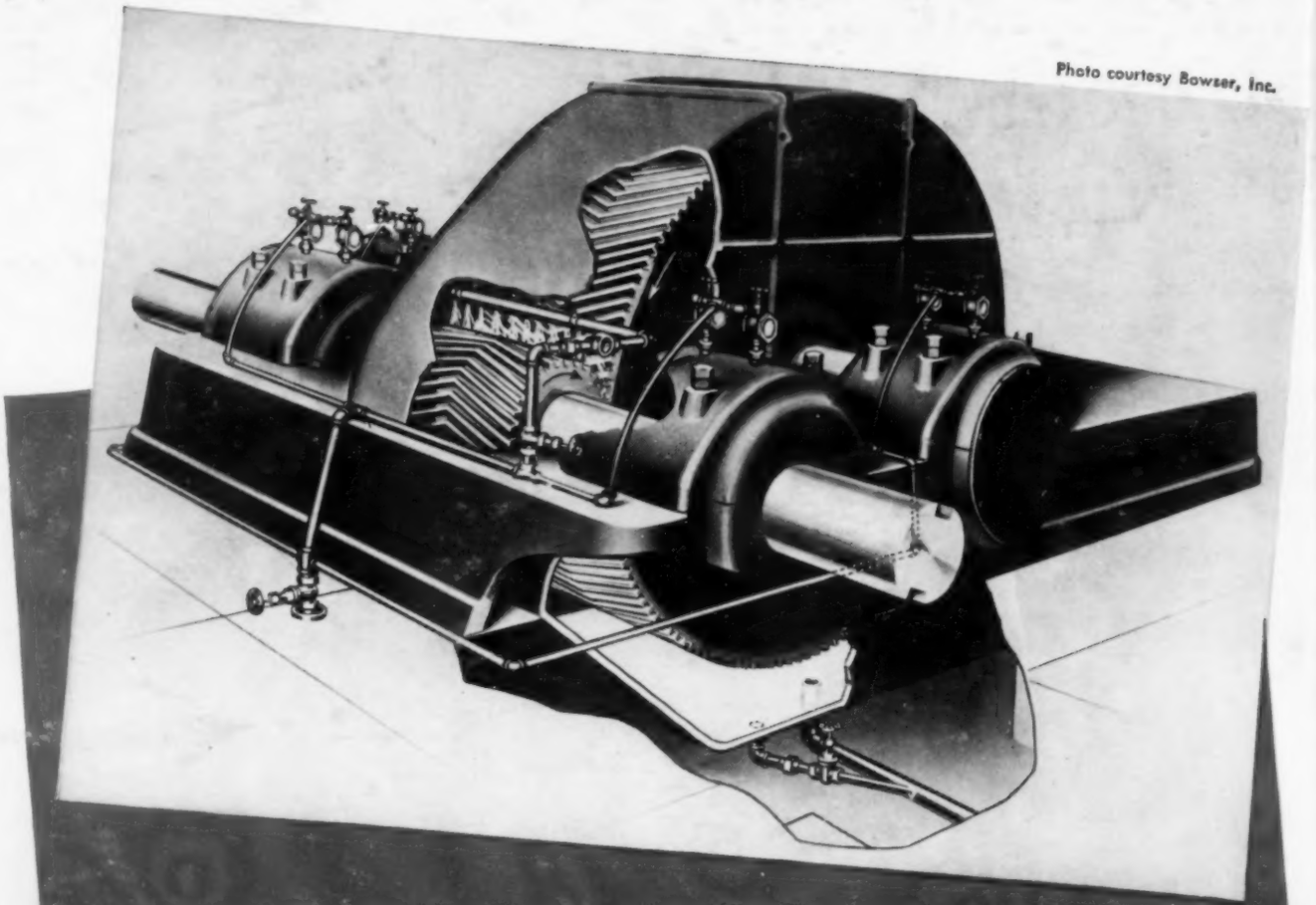


FARVAL—*Studies in Centralized Lubrication No. 92*



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